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THE SEAGOING SUCTION DREDGE "THOMAS," one of the two dredges being built for the New York Harbor improvements, was launched at the yards of the Maryland Steel Co., at Sparrow's Point, Md., on Oct. 2. The dimensions of the dredge are: Length, 300 ft.; beam, 52½ ft.; depth of hold, 26 ft. The engines are triple-expansion, with cylinders 10, 28 and 45 ins. in diameter, with a piston stroke of 28 ins. The dredging apparatus, which includes a 48-in. centrifugal pump and suction pipe 40 ft. long, is in the forward part of the dredge. The hopper capacity of the dredge is 28,000 cu. yds.

WORK ON THE QUEBEC BRIDGE, across the St. Lawrence River, was formally inaugurated on Oct. 2, when Sir Wilfred Laurier laid the cornerstone of the first abutment pier. The structural features of this bridge were described briefly in Engineering News of Sept. 20, 1900.

A SMALL WATER PURIFICATION STATION at New Orleans will be installed at once for the investigation of the most practicable processes for the purification of the Mississippi River water. A contract for settling and coagulating basins was let by the city on Sept. 12 for $4,373. The plant will be located in Audubon Park, near the State Experiment Station. There will be a number of settling, coagulating and filtering tanks, the latter including slow sand and mechanical filters. Definite engagements covering some months to come have been made with Messrs. Rudolph Hering, M. Am. Soc. C. E., and Geo. W. Fuller, Assoc. M. Am. Soc. C. E., of New York city, to serve on the advisory board of engineers for the sewerage and water-works improvements, and Mr. R. S. Weston, of Boston, Mass., has been appointed Resident Expert in charge of the water purification investigations. Mr. Geo. G. Earl, M. Am. Soc. C. E., General Superintendent of the Sewerage and Water Board, is carrying on a number of other preliminary investigations relating to the proposed water and sewerage works, in order to secure needed data for the proper design of the works. The local members of the advisory board of engineers are: Major B. M. Harrod, Past Pres. Am. Soc. C. E., and Messrs L. W. Brown, M. Am. Soc. C. E.; Thos. L. Raymond, M. Am. Soc. C. E., and A. C. Bell, C. E.

MORE WATER FOR ALLEGHENY, PA., will be provided by a large increase in pumping capacity if a proposed bond issue is placed before and endorsed by the voters. It is said that large quantities of water are still taken from the river at the old station, in or near the city, at times when the demand exceeds the capacity of the new pumping station at the Montrose filter crib. There is talk of increasing the pumping capacity at Montrose from 36,000,000 gallons, the present capacity, to 60,000,000 gallons a day and of laying a new force main alongside the 60-in. steel main. The filter crib was described in our issue of May 17, 1900, and the steel conduit in our issue of Oct. 10, 1895. As we stated in our article on the filter crib, Allegheny is notorious for its enormous water consumption and waste; we also said that the city had only 12 meters in use at the close of 1899, and that it was doubtful whether the results obtained from the large filter crib warranted the expense of its construction. If still more water is taken from the crib its value will be even more questionable than formerly, and at the same time water waste may be expected to mount up higher than before.

A NEW WATER SUPPLY FOR CHARLESTON, S. C., is to be developed by the Charleston Light & Water Co., under a contract just authorized by the city council. The new company is to pay the company now supplying the city $350,000 for the present works. It is to build new works in accordance with plans made by Mr. J. L. Ludlow, M. Am. Soc. C. E., of Winston, N. C., which provide for a supply from the Edisto River, to be filtered and pumped. The city is to have the right to buy the works.

PLANS FOR WATER CLARIFICATION at Richmond, Va., are still under consideration. A tentative scheme, reported as devised by Messrs. Cutshaw and Bolling, City Engineer and Superintendent of Water-Works, respectively, is to enclose a basin at one side of the bed of the James River, which would be shut off from the river in times of flood. Water would be pumped from the basin to the city reservoirs.

THE 48-IN. AUXILIARY CAST-IRON WATER MAIN for Brooklyn, known as the Millburn conduit, seems to be assured, as the ordinance providing $1,010,000 for its construction, noted last week, has been approved by Mayor Van Wyck.——Another prospective addition to the available water supply of Brooklyn is the construction of two small mechanical filter plants to purify the water from two streams or ponds cut off from the supply because of pollution. Bids for these plants were received on Oct. 4, as noted under "Water-Works," in our Construction News Supplement for this week.

FURTHER SEWAGE POLLUTION SUITS against New Britain, Conn., were begun on Oct. 5. A total of $26,000 damages are demanded by six plaintiffs for the pollution of the Mattabessett River, in the town of Berlin.——Residents of Red Bank, N. J., have applied to the New Jersey State Sewerage Commission for relief from the pollution of the Navesink River. The commission will hold a hearing on the matter on Oct. 15. Mr. Boyd McLean is secretary of the commission, the office of which is in the Fuller Building, Jersey City.——The New York State Court of Appeals has ordered a new trial in a suit of long standing brought to prevent the pollution of Oaatka Creek by the discharge from salt works and also to prevent the diminution of the flow of the stream. The original case was brought in 1892 by Wm. D. Strobel against the Kerr Salt Co., one of numerous companies on the creek, all of which are now controlled by the National Salt Co. The water from the creek was used to mine salt from wells on the saturation system, the wastes from the evaporation pans going back to the creek. Farmers claimed that the water was unfit for their cattle, and the plaintiff urged that the salty water injured machinery in his mill, located on the stream. Two lower courts decided in favor of the defendants, that their use of the creek was a reasonable one. If the new trial, just ordered, reverses these decisions numerous other suits are expected. The stream in question is a tributary of the Genesee River, and is sometimes known as Allen's Creek. It joins the river not far above Rochester, after passing through Le Roy and Warsaw, N. Y.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Pittsburg & Western Ry. at Gibsonia, Pa., on Oct. 2. A runaway freight train ran into the rear end of another freight train which had stopped in front of it, completely wrecking both trains, killing three men and seriously injuring six others.

THE BUILDINGS COVERING THE BUFFALO GARbage reduction works were burned on Oct. 1, leaving the city and the contractor for reducing the garbage in a plight pending arrangements for temporary disposal in a sanitary manner.

THE STEAMER "MAIN," of the North German Lloyd Line, which was badly damaged by fire when the Hoboken piers of the line were destroyed last July, will, it it stated, be repaired in the United States at the yards of the Newport News Shipbuilding Co. The estimated cost of the repairs is $600,000, and it will take about twelve months to complete them.

THE LARGEST CARGO OF IRON ORE ever moved on Lake Superior by a single engine was recently carried by the steamer "Maricopa" and two barges of the Minnesota Iron Co. The two barges were towed by the steamer and the three carried 22,635 tons of ore. The average speed made by the tow was eleven miles per hour and the combined crews numbered 41 men. At the season contract rates this shipment would bring the vessels $27,956.

A LARGE STEEL CAR-FERRY BOAT is being built for the Pere Marquette Ry. for use in carrying cars across Lake Michigan. The dimensions of the new boat will be: Keel, 338 ft. and 350 ft. over all; beam, 56 ft.; molded depth, 36½ ft. The boat will carry 32 loaded cars at 14 miles per hour. The twin screws will be driven by two triple-expansion engines, which will be furnished with steam from four Scotch type boilers.

A CANAL FROM LIEGE TO ANTWERP, Belgium, to connect the prosperous city of Liege with the sea and make it, like the city of Manchester, England, a seaport, is seriously talked of. The original promoter of the scheme was Mr. Joseph Redoute, who is now dead. Mr. Redoute's plans have recently been put into practical shape by Messrs. Louis Hubin and Gaston Delville, who propose a canal 84 miles long, 200 ft. wide and 23 ft. deep from Antwerp to Liege, with docks at Liege, Hasselt, Herenthals and Antwerp. The difference in level to be overcome by locks would be 175 ft., and it is thought that 13 single locks and one double lock would be sufficient. Electric haulage would be employed and the locks, bridges, and dock machinery would be operated and the canal lighted by electricity. The total estimated cost of the work is $25,200,000.

THE COOLGARDIE PIPE LINE in Western Australia will be built in embankments wherever the line crosses "salt lakes" or "salt pans." The experiments noted on p. 179 of our issue of Sept. 13, 1900, have, after mature consideration, led to the conclusion that it would not be safe to bury the pipe in the salty soil in question. The embankments will be of material impervious to the salt, and will be wide enough to allow the pipe to be covered. We are indebted to Mr. C. Y. O'Connor, Engineer-in-Chief, and to Mr. Ernest E. Salter, Assistant Superintendent of Public Works, Perth, West Australia, for the information given.

TRACTION ENGINES and steel wagons are being built by the Best Manufacturing Co., of California, for use in Siberia, where they will serve as a substitute for camel trains. The engines, which are quite fully described in the London "Engineer" of Sept. 28, differ from the ordinary type of traction engine, having three wheels and a vertical boiler. The latter is provided on account of the steep gradients that the engines are called upon to surmount. The boiler sits directly over the main axle and in front of it is a horizontal water tank of about 500 gallons capacity. The engine is rated at 50 HP., weighs 14 tons and is intended to travel at three to six miles per hour with four loaded wagons. The wagons weigh empty about 4½ tons and are rated at a carrying capacity of 16 tons of goods.

PRESSED STEEL BARRELS for shipping oil and other materials requiring a light but strong barrel has been put onto the market by Mr. J. E. Phillips, of Joliet, Ill. The sides of the barrel are corrugated in horizontal rings and the heads are formed from the same sheet or are integral with the sides. The upper half of the barrel is made from one disk of sheet steel and the lower half from another disk. Each disk is placed in a special die press which cold presses it into the requisite form for one-half of the finished barrel. The two halves are then butted together and welded by electricity. Made from 3-16-in. steel a 52-gallon barrel weighs 40 lbs. and will withstand an internal pressure of 65 lbs. per sq. in. These barrels are also made with a removable head.

PHOTOGRAPHY ON THE RAPID TRANSIT RAILWAY work in New York city is to play an important role. It it to be used not only to record the progress of work, but as a means of keeping evidence for use in possible damage suits. Before work is begun the locality is photographed from several different points of view and then photographs are taken monthly thereafter. When a leaning building is met along the work or a cracked cellar wall is uncovered it is photographed and the picture is filed for use in case claims for damage are subsequently made by the owners.

THE TAMARACK MINE SHAFT, one mile deep, which was begun in 1895, will, it is expected, be completed by January, 1901. When completed this shaft will be the deepest mine shaft in the world.

DISAPPEARING CARRIAGES FOR HEAVY GUNS for coast fortifications have been reported against by the Board of Ordnance and Fortifications which has recently been considering the question in a protracted meeting at Washington, D. C. Briefly stated the Board has recommended to the Secretary of War that no more disappearing gun carriages be made. The reasons for the decision have not been made public.

THE MANCHURIA RAILWAY, according to an official statement of the Russian Minister of the Interior, has been destroyed for about 400 miles by the Chinese rebels. Immediate repairs have been decided upon.

A SHIP FOR THE GERMAN SOUTH POLE expedition next year is being built at Kiel, Germany. It will be a three-masted schooner with triple sheathing of oak, pitch-pine and green-heart. It will be provided with triple-expansion engines, which will be designed to give a speed of seven knots. All available space will be used for coal bunkers. The ship will carry a 20-ft. naphtha launch and a captive balloon apparatus. A wind-mill will be provided for working the dynamo when the boiler is not under steam.

BACTERIAL STUDIES OF THE HEALTHFULNESS OF STREET PAVEMENTS OF LAFAYETTE, IND.

By Daniel B. Luten and Severance Burrage.*

The question of selecting the most suitable pavement has become one of serious moment in the last few years, with the wonderful growth that has taken place in street improvements in all wide-awake cities and towns. There are many factors that enter into the determination of the value of the various pavements, such as durability, cost, smoothness, ease of repair, and so on; but one of the most important, although frequently given but small consideration, is the healthfulness of the pavement.

Fig. 1.—View of Apparatus Used to Collect Samples of Street Dust for Bacterial Analysis at Lafayette, Ind.

There exists a popular prejudice against wood block pavements on the ground that they are unhealthful. This prejudice appears to be based on the reports of several investigators who have analyzed samples taken from the surface of pavements, and found the wood block samples teeming with germs, whereas asphalt and brick were practically free from them. There seems to be, however, one element that has not been taken into account by these investigators; they have drawn their conclusions on the basis that the most unhealthful pavement is the one that contains, or retains, the greatest number of germs. This inference is, perhaps, rather hasty, for it must be admitted that that pavement is the most unsanitary which transmits, or allows to be transmitted, the greatest number of germs to the human system. And it is possible that the pavement that contains or holds the greatest number of bacteria may not be unsanitary, provided that it retains them, and does not permit them to escape into the air.

It is further advanced by some, that the pavement is unsanitary only when it permits filth to permeate the foundations and the soil. As a matter of fact, the only danger from this source is the pollution of wells, and that is very slight. The real unhealthfulness, from a bacteriological standpoint, depends upon the number of germs that escape from the surface, are borne about in the air as dust, and sooner or later reach the human system. If more bacteria escape from the pavement that contains within its substance the greatest number of germs, then that pavement must be regarded as the most unsanitary; if, on the other hand, that pavement, whose substance contains or retains no germs, allows the greatest number of bacteria to escape from its surface, then that pavement must be regarded as unsanitary.

To investigate this question from a more scientific standpoint, experiments were undertaken in the fall of 1899 on the various pavements of Lafayette, Ind., the object of the experiments being to determine, if possible, the relative number of bacteria liable to be inhaled by breathing the air over the various pavements. Bacteriological examinations of the dust in the air over these various pavements were made in the following manner: 4-in. Pasteur dishes, containing films of sterilized agar, were exposed in duplicate for exactly ten minutes, at a height of 5 ft. above the pavement. The velocity of the wind was taken by means of an anemometer fitted with a wind-vane, suspended 1 ft. above the pavement, the whole apparatus (including agar plates resting on a book on the summit of the tripod), being shown in Fig. 1.

The various exposures were made under conditions as nearly similar as possible. The factors which might affect the results in each exposure were, however, so numerous that it was almost impossible to control them. The best that could be done was to make a large number of exposures and average the results. Such a method is necessarily subject to a large element of chance; the writers, therefore, do not propose to draw final conclusions from this comparison of averages. But the actual experience of attempting to control conditions and secure uniform results brought out many valuable points that help to show what conclusions may with safety be drawn.

The pavements tested were of five different varieties: Round cedar block, brick, sheet asphalt, asphalt block, and macadam. The cedar block is eleven years old, badly worn, and is in about as bad condition as it can be. The foundation is of gravel and plank. The blocks are round, with the interstices filled with gravel and sand.

The brick pavements were from three to five years old, of good No. 1 pavers on a concrete base, and grouted with cement grouting. The wear has been very slight, and the pavements are in excellent condition. The asphalt block pavement was laid in the fall of 1899, on 4 ins. of concrete, and grouted with sand. The block are the copper ore tailings block, manufactured at Toledo. The sheet asphalt was laid in 1899, analysis showing about 83% of rather fine sand, 11% of bitumen. The macadam pavements were all in bad repair, and very dusty.

All the experiments were performed upon pavements in close proximity to one another, and so far as possible on parallel streets. Unusual sources of germs, such as livery stables, were carefully avoided. The pavements are cleaned regularly twice a day by hand-scrapers. No attempt is made to sweep up the finer dust except where it has gathered into heaps by wind action. Considerable amount of mud is carried onto the pavements from cross streets, which are covered with gravel or macadam. The conditions in this respect were quite similar for the various kinds of pavements. The pavements are not sprinkled, with the exception of the wood-block, which received a sprinkling perhaps twice daily, and which is noted with each individual experiment.

The experiments were begun in October, 1899. The numbers of bacteria resulting from the exposures were obtained by permitting the agar plates to incubate for three or four days, and then counting the colonies of bacteria and molds that had developed on the agar. Each colony is supposed to have been the product of a single germ that had fallen upon the agar, and as the plates were all of uniform size, 4 ins. in diameter, and the exposures for exactly the same length of time, these results ought to give a good means of comparison.

The first experiment gave results as follows, expressed in bacteria per plate: Wood-block, 425; brick, 466 and 784; sheet asphalt, 436 and 1,320.

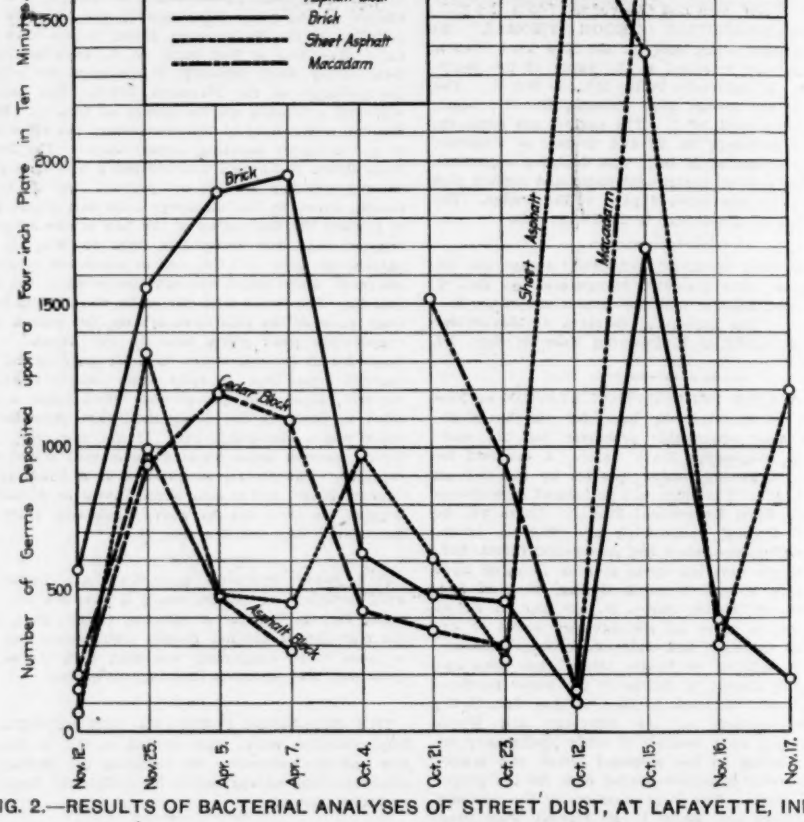


FIG. 2.—RESULTS OF BACTERIAL ANALYSES OF STREET DUST, AT LAFAYETTE, IND.

All the exposures, as made under normal conditions, are tabulated below. There are so many factors that materially influence the amount of floating dust, such as the amount of traffic, the velocity and gusty nature of the wind, that all of these must be considered in studying the results. The diagram, Fig. 2, is added in order to better represent the relations shown by these exposures for the various pavements. The dates of observation are arranged in the order indicated merely to make the curves continuous, since all of the pavements were not tested on all occasions.

Obviously no general law can be deduced from the results of these observations. The curves show no characteristic tendencies; nor does any rearrangement of observations with respect to seasons bring out any law. The asphalt block gives decidedly low figures on all occasions; but the number of tests on this pavement was necessarily limited, because of the fact that that pavement

*Instructors in Civil Engineering and Sanitary Science, respectively, Purdue University, Lafayette, Ind.

was not opened to traffic until after the investigation was nearly completed.

It is quite clear, however, that the charge of unhealthfulness commonly made against wood-block pavements receives no support or confirmation from these experiments.

Now as to the conclusions that may safely be drawn from these observations: The unhealthfulness of wood-block pavements from a sanitary point of view has not been proved by previous investigators; an investigation that analyzes the pavement itself, and not the refuse from the pavement, cannot be relied upon to measure the unhealthfulness of the pavement; the most impervious pavement is not necessarily the most sanitary pavement.

FIGS. 3 AND 4.—VIEWS SHOWING DUST RAISED BY A STIFF BREEZE FROM SHEET ASPHALT PAVEMENTS IN LAFAYETTE, IND.

No definite relation could be traced between the recorded wind velocities and the number of germs. This is doubtless due to three causes: The gusty nature of the wind, the impossibility of devising a method of measuring the velocity of the wind that actually raises the germs from the surface; and the fact that a high wind may actually have swept the surfaces of some of the smoother pavements nearly free from dust, so that when the exposure was made, the higher wind velocity gave a lower number of germs on these pavements. This was especially noticeable on sheet asphalt. The lower figures on the diagram were obtained on pavements which had been swept clean by the wind.

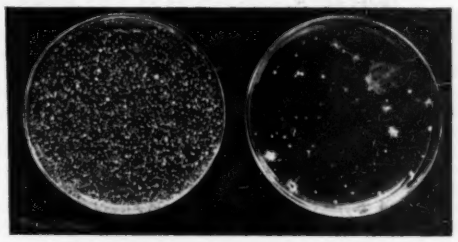
The wind undoubtedly plays a most important part in the transmission of the germs, although the device employed was not ingenious enough to detect it. The relation was easily studied, however, by observation of the movement of the dust on and above the pavement. It was possible to predict with considerable certainty that specific exposures would result in high or low bacterial figures. Light clouds of dust caught up by the wind and carried near the agar plate invariably gave a high number of bacterial colonies. The maximum effect seemed to be produced when the pavement had been for some time free from wind influences, and then subjected to a breeze that set the dust flying.

The writers firmly believe that the unhealthfulness of a pavement depends, not upon the power that a pavement may have to retain and breed germs, but upon the ease with which the dust, including bacteria, is stirred from its surface by the wind; and that clouds of dust arising from the pavement are sure indications that clouds of germs are also escaping into the air.

It may remain to be proved that the clouds of bacteria thus escaping into the air include pathogenic forms. It might be argued that the damp fibrous pavement allowed the germs to multiply in great numbers, while the dry impervious pavement would tend to destroy them, leaving only those that are not dangerous. As to the possibility of pathogenic forms occurring on the pavement, it is only necessary to mention that the sputum of consumptives and otherwise diseased persons and the offal of horses and other animals that may be diseased, finds lodgment upon the pavements, and being ground up into fine particles by the wheels, sooner or later becomes flying dust.

A somewhat limited study was made into the wind velocities required to move the dust from the various pavements, and it was found that under the local conditions obtaining on the different pavements, dust was moved on sheet asphalt by a velocity of about 300 ft. per minute; on brick, about 500 ft. per minute; and on asphalt block, 600 ft. per minute. Wooden block was almost entirely free from dust clouds. These wind velocities are doubtless dependent to a large extent upon local conditions. It is not believed that they should be generally accepted, but that the safest guide toward judging the sanitary value of any pavement is by direct observation as to the dust clouds given up by the pavement; such observations must be comparative between the different kinds of pavements, and must extend over long periods. In short, the safest guide to the amount of dust would, perhaps, be the testimony of residents having had experience with the various pavements.

The dust given off by sheet asphalt and macadam is apparently of a much finer texture than that yielded by brick or asphalt block. This may be determined by actual examination of the dust particles on the surface. It is also a fact corroborated by several observers that the dust flying from sheet asphalt under a heavy wind does not strike the face and hands with the intensity shown by the dust particles from brick or asphalt block. The particles blown from the latter pavements sometimes produce decidedly sharp and painful blows. This of course indicates the finer nature of the dust on the sheet asphalt and macadam pavements. This finer dust, moreover, is the more dangerous to health, acting as an irritant to the delicate membranes of the eye, nose and throat. This is all in addition to the fine, practically invisible dust that is made up of the spores of bacteria and molds.



Sheet Asphalt; 2,850 colonies. Brick; 99 colonies.

Fig. 5.—Relative Numbers of Bacteria from Brick and Sheet Asphalt Pavements, Lafayette, Ind.

There is, of course, no necessity for explaining the dustiness of macadam streets. When they are made of soft or brittle stone, as is usually the case in cities far removed from trap-rock sources, and when poorly maintained, they are invariably dusty. In and about Boston, where macadam may be seen at its best, the citizens are waging war against these pavements, because in the winter they are very dusty and cannot be sprinkled, and in the summer time, no amount of sprinkling seems to be sufficient to keep down the dust.

With sheet asphalt the fineness of the dust is perhaps due to the fact that the pavement consists of about 80% of sand, and the surface has an actual sandpaper-like appearance, which may serve to grind the surface dirt into finer particles.

Figs. 3 and 4 show clouds of dust raised from sheet asphalt pavements in Lafayette by a stiff breeze, when the cross streets were still damp from a recent rain; there is, therefore, no doubt that the dust rises from the pavement. These pavements here shown had been twice cleaned the day before by hand-cleaning methods, the ordinary scraper and broom being used.

Evidently the remedy for this condition of things is better methods of cleaning, these systematically carried out, or else generous sprinkling which will lay the dust and furnish a moist surface that will retain the finer dust and bacteria.

There are several other considerations to be taken into account in judging the healthfulness of street pavements. Some pavements are known to reflect the heat more than others, and in certain climates would on this account be undesirable. Then again, pavements that are all the time damp, may have a depressing effect upon the people of the neighborhood, making them more susceptible to various diseases. Certain forms of wood-block might bring about such conditions; but, on the other hand, the death rates of cities having a

Observations on Bacteria in Street Dust, Lafayette, Ind.

Date.	No. bacteria in 10 mins.					Wind velocity		Remarks.
	Block—Asphalt.	Block—Wood.	Brick.	Sheet asphalt.	Macadam.	Feet in 10 mins.	Max., ft. per min.	
October 4, 1899	.....	425	.....	.....	.....	.....	.....	
	.....	...	466	.....	.....	.....	.....	Dry; wind from street.
	.....	...	784	.....	.....	.....	.....	
	.....	...	...	436	.....	.....	.....	Dry; wind from lawns.
	.....	...	...	1,320	.....	.....	.....	Dry; wind from street.
October 12	.....	...	99	...	.....	1,780	.....	Dry; medium traffic.
	.....	...	...	2,850	.....	1,000	.....	Dry; heavy traffic.
	.....	...	...	...	147	250	.....	Muddy; no dust.
October 17	.....	...	1,680	...	...	2,300	.....	Dry; dusty.
	.....	...	...	2,372	...	3,230	.....	
	.....	...	...	...	2,920	3,255	.....	Damp; slightly dusty.
October 21	.....	352	...	...	...	1,670	.....	
	.....	...	476	...	...	470	.....	Damp, from sprinkling.
	.....	...	...	615	...	400	.....	
	.....	...	...	...	1,520	1,200	.....	
October 23	.....	304	...	...	...	3,650	.....	Damp, from sprinkling.
	.....	...	463	...	...	2,830	.....	
	.....	...	...	180	...	5,840	.....	Dry; wind swept.
	.....	...	...	327	...	4,080	.....	
	.....	...	...	...	958	2,200	.....	Dry; dusty.
November 12	195	...	...	...	...	2,300	330	Dry, dusty.
	...	147	...	...	...	2,000	290	Dmp; sprinkled 24 hrs. befr.
	...	...	562	...	...	2,500	600	Dry.
November 16	...	...	...	65	...	2,580	550	Dry; dusty.
	...	...	380	...	...	3,600	425	Damp.
November 17	...	...	...	310	...	4,800	585	Dry; clean.
	...	...	170	...	...	2,800	350	Dry; dirty.
	...	...	...	1,195	...	5,000	650	Dry; dusty.
November 25	980	...	...	...	...	3,600	400	Dry; clean.
	...	932	...	...	...	2,000	250	
	...	...	1,560	...	...	3,000	350	Dry; dirty.
	...	...	...	1,200	...	3,200	450	Dry; flushed 8 hrs. before.
	...	...	...	1,880	...	3,700	470	Dry; dirty; dusty.
	...	...	...	755	...	3,000	400	Dry; flushed 4 hrs. before.
April 5, 1900	474	...	...	...	...	2,900	550	Dry; dirty.
	...	1,180	...	...	...	1,400	300	Damp; clean.
	...	...	1,880	...	...	2,500	400	Dry; clean.
	...	...	...	470	...	2,800	510	
April 7	276	...	...	...	...	3,200	350	Dry; dusty; dirty.
	...	1,000	...	...	...	1,000	250	Damp; dirty.
	...	...	1,950	...	...	2,000	400	Dry; dirty; dusty.
	...	...	...	450	...	1,800	250	Dry; wind swept.
	...	...	...	...	11,250	3,000	350	Dry; clouds dust; hvy trafc.
Average	480	630	870	1,030	.....	.....	...	

large percentage of wood-block pavements do not seem to show any increase over other cities.

Several experiments were made to prove that the pavement was the source of the bacteria deposited on the agar plate during the exposure. For example, exposures were made after midnight (on Oct. 4, 1899), when there was no traffic, and very little, if any, wind, with the following results in bacteria per plate: Macadam, 9; sheet asphalt, 14 and 8; wood, 50; brick, 16.

Fig. 5 contrasts the number of germs found upon the plates exposed on brick and on sheet asphalt, Oct. 12, 1899, as shown by photograph of the plates. The plate exposed on brick had 99 colonies, and the one on sheet asphalt had 2,850 colonies.

PRACTICAL HINTS REGARDING ELECTRIC TRAVELING CRANES FOR FOUNDRY USE.*

By A. D. Williams.†

In nearly all foundries, cranes are employed to do heavy lifting, and the overhead traveler, in most cases using electric power, has become a very desirable part of foundry equipment. The idea in this paper is to consider the multimotor electric crane from the user's standpoint, taking up its desirable and undesirable features, without attempting to give a detail treatise on crane designing. The only machines that never break down are those which are never used. Cranes are no exception to this rule, and the natural depravity of inanimate objects always causes the selection of such a time as will result in the greatest possible inconvenience to all concerned. Many serious crane accidents have occurred and some of these are no doubt fresh in the memory of Pittsburg foundrymen.

The slings used in handling loads are really not part of the crane, but they are a source of trouble. Chain slings are the best, they are flexible, do not chafe, and damage to finished surfaces can easily be prevented by a little care in using. Their periodical inspection is necessary; and they should be annealed from time to time. Rope slings are liable to cut and are uncertain. In many places their use has been stopped, after an accident has cost more than a good set of chain slings.

For hoisting purposes chain is most commonly used on account of its flexibility, this means smaller drums and sheaves, and a higher hoist than can be obtained on the same crane with wire rope. Only the best grade of tested chain should be used. As this becomes fatigued by long use, small cracks may develop. Its durability of course depends on the service the crane gets, and defects are not easily detected. Chains should be kept well lubricated, and annealed occasionally. Where wire rope is used its condition is readily seen, no expert being required. In this respect it is safer than chain. Extra flexible wire rope is manufactured which is well adapted to crane service on account of the moderate size of the sheaves and drum required. It is not an experiment for hoisting purposes, but its use on electric cranes is not as common as it would be if its good qualities were thoroughly appreciated.

Hooks are made of various materials, forgings of wrought iron and steel are used in many cases, but malleable iron and steel castings are also employed. Malleable castings are only used for very light sections. For heavy work forged hooks are universally employed, and cast-steel hooks have been used for medium size cranes. A first-class steel casting is much better than a poor forging, though the material to be specified is largely a matter of individual preferences. With proportions suited to the metal, it makes very little difference what is used, the chances of flaws are about even, and a burnt forging is not any more reliable than a defective casting.

Come cranes are so constructed that in hoisting and lowering the load is twisted more or less around a vertical axis, this necessitates extra care in its guidance. This style of hoist is not well suited for foundry purposes, as the attempt to correct this twisting can be very easily overdone with disastrous results. For the foundry a vertical hoist without any twist in it fills the bill best, and for almost all purposes is the most desirable.

The electric motors, controllers and wiring on cranes should all be arranged and constructed so that repairs can be easily and quickly made. Perfect insulation is impossible, as all substances conduct electricity more or less. There are a number of grades of insulated wire, and a good quality run on porcelain insulators or in molding arranged so that no two wires can come in contact with each other or with any metal should be insisted upon. Nearly all the electrical troubles with cranes arise from imperfect insulation. No detail is too small to be slighted in this respect as fine dust and "flyings" are liable to settle anywhere, and a ground or short circuit from this cause may be expensive. Wooden battens should be used to prevent the trolley from swinging against the girders, but wood alone should never be depended upon as an insulator.

*Slightly condensed from a paper read before the Pittsburg Foundrymen's Association.

†Shoenberger Steel Mills, Pittsburg, Pa.

Crane controllers are important, as the entire manipulation of the machine depends upon them, this like the clutch of the mechanically operated crane is a weak point. The practically perfect crane controller is yet a matter of the future. All parts should be accessible, and so arranged that those subject to wear can be removed and replaced with a minimum amount of trouble. The resistance coils should be arranged so that close control over the crane can be obtained, as without it delicate handling is impossible. The device by which the operating levers are centered, or held in the position at which the current is off, should be so positive that the operator is not likely to throw the lever too far and reverse unintentionally. Any weakness in this device is a constant source of danger, yet it is desirable to have easy working controllers.

The electric motors used should be enclosed in dustproof casings; those built for crane service by the large electrical concerns are very compact and accessible, their designers have had the benefit of wide experience gained in street railway work, and the motors they produce give very little trouble. Standardization of all parts has been followed out, so that repairs are in most cases very simple, and extra parts can be carried in stock. Special motors are things to be avoided, a bill for repairs would furnish sufficient explanation. The armature and commutator of a motor are its two most vulnerable parts, and it is much easier to remove them when attention is required than to attempt their repair in place. In most cases removal is absolutely necessary. A set of spare armatures adds to the cost of a crane, but it will save a delay at an inopportune time, as slight faults can be corrected which, if given time to develop, would prove expensive.

Crane brakes or safety devices are of two kinds—one which acts upon the interruption of the electric circuit for any cause; the other operated by the load. The former is generally called the magnetic brake, because it is thrown out of action by magnetism, being thrown on by a spring or by gravity. The force of gravity is not very likely to fail, springs are not so reliable. The braking effect is obtained by a cast-iron drum keyed to one of the shafts (preferably the armature shaft) where its effect will be greatest, and a brake strap acting on the drum. This strap is often made of sheet steel and its friction surface fitted with a renewable lining of wood, leather, or other suitable material. Naturally this brake strap required adjustment from time to time to take up the wear. This brake is made single or double acting, its principal duty is to overcome the inertia of the armature and to stop the load promptly. It should, however, be of sufficient size to hold the load. The designing of one of these brakes presents some interesting problems. Too little of it is only an aggravation, and when too large it is troublesome and may twist a shaft in two by stopping one end before the other. A modification of the Weston disk brake has also been successfully used as a magnetic brake.

The load brake, variously called the automatic brake, safety retaining clutch, mechanical brake, etc., is made in a number of designs by different makers, the basic principle is the same in all. The tendency of the load to run down acts to set the brake, which is arranged to permit hoisting freely. In lowering the motor acts against the tendency of the load to lock the brake, and the load cannot move until these two forces balance each other; the brake absorbs the acceleration of gravity on the load so that it can only drop at a speed proportional to that of the motor. It might be said that the motor has to push the load down, this does not describe the action accurately, but it is close to it. It is highly important that the operation of this device should be smooth, any irregularities in its action causes the load to descend in a jerky fashion, which means excessive strains in the whole structure, and tends to develop defects. While no apparently serious results may appear at the time, there is the ever-present risk that some part may have been overtaxed and cause a seemingly inexplicable breakdown in the future.

The mechanical elements of a crane are very simple, a few gears, track wheels, shafts, the motors, drum brakes and the necessary framing to support and hold the mechanism, is about all there is to the trolley, but it will not do to put this together in "any old way." The phrase, "in a workmanlike manner," is susceptible of various interpretations, as there is no particular standard, and each one must judge according to his own lights. It is hardly necessary to say that cost counts in cranes as in everything else. The crane builders are not in it for pleasure, and the shop facilities as well as the number that can be built from one set of patterns is important; all changes add to their costs and the endeavor is to get up a set of standard sizes that will enable them to suit the general run of customers with most of whom the price decides the question. The maximum amount of trolley travel calls for a short trolley. The minimum of headroom can only be entered by a low trolley. The maximum amount of hoist can only be obtained by a trolley which can be placed close to the roof chords. Ease of repair requires that all parts shall be arranged so that any piece can be removed and replaced with a minimum amount of trouble and labor. All bearings should be capped, as shafting has a habit of getting bent so that it is impossible to remove it from a solid bearing without cutting it to pieces. With hack saws this is a tedious job, but it can be done very rapidly by burning the shaft in two by an electric arc, provided power enough is available. With capped bearings bent shafts can be removed and straightened; perhaps they ought not to become bent, but it does happen just the same. With cranes it is not easy to make repairs; the space to move around is limited and the risk of a tumble makes a man cautious; often only one hand is available. This fact is not thoroughly appreciated as it should be by crane designers.

Crane gears are important items, particularly as they wear out in time. Cast-iron gears, if properly proportioned, work well, but it is a good plan to have pinions of steel. In this combination the pinion wears out before the gear. In a great many cases a little more iron would improve the gears. Where this is the case, cast steel can be used to advantage in making repairs, as owing to the limitations of space, etc., it is rarely possible to make any changes in the main dimensions. Lightness is particularly important in a crane, as it counts in the girders requisite, but a crane that is too light is continually giving trouble, and in the long run it costs more than a heavier machine.

Safety devices of different kinds are occasionally employed to prevent over hoisting, and running the trolley or bridge full tilt into the end stops. Their utility is questionable, for the crane operator can hold the circuit breaker in and at the same time use the controller to get back past the safety line. The best arrangement of such devices is to so place them so that the operator will have to call assistance to hold the circuit breaker in until he can run back to a point where it will stay closed. When the operator finds that he gets caught in this way it is only a matter of time before he discovers a way to get around the circuit breaker. Over hoisting generally brings a pretty good strain on the mechanism. It is very likely to result in broken chain sheaves and a bending of shaft. One accident of this kind is about all a crane operator should have charged up to him, and unless he loses his head the results are not very serious. Running the trolley or bridge into the end stops at full speed is a very efficient way of testing the strength of the crane girders and runway, but there is a certain amount of danger in it, so that it is not advisable to do this intentionally. It is an expensive job if anything fails, and more than one crane has refused to stop at the end of the runway. This accident has also been caused by high winds, showing that for a yard crane a good anchor is necessary. The longitudinal and lateral strength of a great many crane runways is much lower than it should be, as only the static loading is considered and the roof trusses are depended upon for sway bracing. As they are not designed for this, the whole building is easily swayed in both directions by the crane.

The track wheels are depended upon, in most cases, for keeping a crane in line, or square, on the runway. These wheels should be of the same circumference. Double flanged wheels of cast steel or cast iron with chilled treads are used; both materials give satisfactory service. Chilled tread wheels should have their flanges made in sand, as otherwise there is considerable liability of the flanges breaking off in case the crane gets badly out of line or the runway varies from gage. With steel wheels the liability of breakage is diminished, but being soft the tread is likely to wear. The flanges are sometimes rolled over and spread apart by a poor runway, this on driving wheels having a gear mounted on their hub forces the gear over so that it cuts into the truck beam. The removal of a steel wheel when this has occurred is a very pleasant piece of work.

It is almost impossible to keep a crane absolutely in line or square, but if proper precautions are taken it is possible to get very fair results. The line shaft should be driven as nearly midway between its ends as practicable, and is preferably a little too large than too small. It may be well to say that what is large to one man may seem small to another. When the line shaft is driven near one end there is a certain amount of torsional spring to it that permits one end of the crane to lag behind, producing a racking action that does not improve the wearing qualities of the machine. This same effect can also be produced by starting the bridge travel suddenly with a heavy load close to one end. It is perfectly practicable to connect the girders and track beams so that this injurious racking tendency can be, to a large extent, overcome, but it is not often done.

Runways that are out of line or not level, or which have a combination of these two defects, do not have a good effect on a crane and cause excessive wear on the bridge driving mechanism. The correction of runway imperfections is comparatively simple, but unless the structure is very thoroughly braced, it will soon be as bad as before.

There are a number of types of crane girders, two connected at the ends being used for all except very light machines. The single webbed plate girder was extensively employed at one time. The bottom chord, however, has a tendency to vibrate considerably when the crane is in motion. This is increased by sudden starts and stops. The weight of the line shaft and motor causes torsional strains and the metal is not well distributed to resist

them. Rapid starting and stopping increase these strains. This type of girder is not suited for high speed cranes unless sway bracing can be used; in this case the trolley is placed between the girders and runs on the bottom chord. Where the trolley runs on the top chord a system of auxiliary latticing can be used, making in effect two girders at right angles to each other and by this means a high degree of lateral stiffness can be obtained at the sacrifice of simplicity.

The double webbed plate or box girder is the simplest form used in crane work; the metal is well distributed to resist all the strains met in service, the rivets can all be driven by machine, the use of stiffeners for the web plates can be avoided by using distance pieces and bolts or long rivets to hold the webs. These girders can be made as stiff as desired, laterally and vertically. Occasionally a girder of this kind is made very deep and light web plates used, but this sacrifices almost all the stiffness and is not very good practice. The principal disadvantage of the box girder is that there is no way to inspect or paint the inside. Lattice girders are used extensively for yard cranes on account of the small amount of exposed surface. They are also employed for long span indoor cranes. The trolley can be placed on either the top or bottom chord to suit the conditions met with.

The failure of crane girders is comparatively rare, as they can generally hold a considerable overload, nevertheless it is not a good plan to use a crane for anything heavier than its rated load, as this has a tendency to develop weak spots that in the future may cause trouble. In some casese a five-ton crane has handled nearly twenty tons, but the operator was taking big chances of spoiling the machine and starting several funerals. The effect of impact on cranes is often neglected. In rapid working these stresses may be equal to those due to the dead load, so that the factor of safety is only one-half of what it would be if these stresses were taken into account in the first place.

Some of the foregoing remarks apply to cranes that are not driven by electric motors, and it is hoped that some information useful to crane users and the prospective purchasers of the machines has been brought out. In the foundry, as well as some other places, it will be found that the electric overhead traveler furnishes no panacea for difficulties inherent to the handling of heavy work, though it is a valuable accessory. A large part of its calls are for turning molds, lifting copes, etc., that are too heavy for the molder. Very often it is necessary to hold such a load for some time, while there may be other floors waiting and losing valuable time. The old foundry jib crane should not be discarded on the advent of the traveler, but rather should be reinforced by a number of light jib or post cranes so that the traveler can be used at its maximum efficiency on lifts proportionate to its capacity.

A great many crane break-downs are due to carelessness or forgetfulness on the part of the crane operator. For instance, he blocks the gearing with a bolt or nut while making some slight repair, then starts the mahine and the firm sends out a rush order for new gears. It is a good plan to carry a set of spares for all parts likely to become disabled or worn out in service; this avoids expensive express charges, and the extra cost of rushed work. In ordering such spares it should be specified that each piece shall be properly marked so that it can be easily identified.

THE "CROSS DRAFT" SMOKELESS FURNACE.

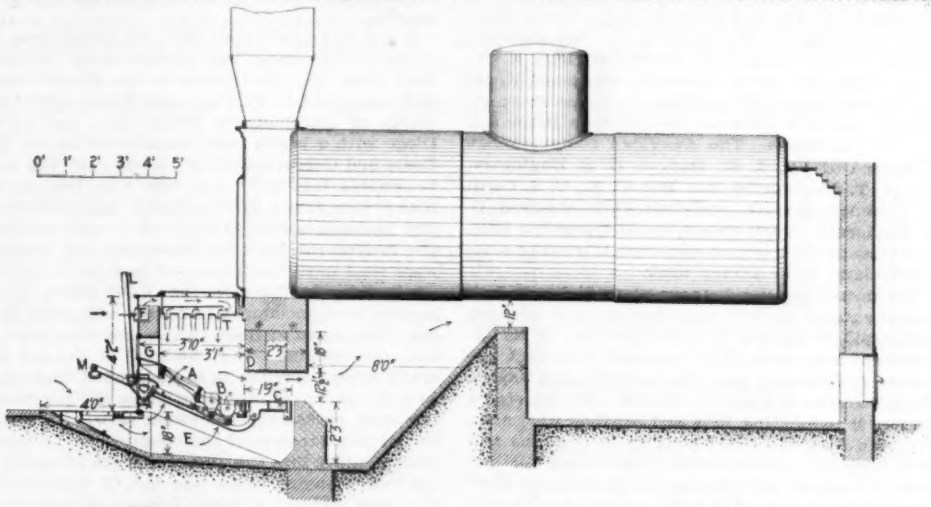
It has long been known that to secure perfect and smokeless combustion three things are necessary, namely: 1, sufficient air; 2, a temperature high enough to cause the gases to unite; 3, a thorough mixture of the air and gases.

The first condition is, of course, easy to secure, but the ordinary type of boiler furnace is not especially suited to bring about a complete mixture of the air and gases at a high temperature. The air comes through the grate in the greatest volumes where the fire is thinnest, while the combustible gases are distilled from the masses of coal last thrown into the furnace. They may pass far on their way through the furnace before they are thoroughly mingled. Meanwhile, by coming into contact with the surface of the boiler the gases are so far cooled that they will not burn. The gases from coal containing much volatile matter are partly decomposed into soot upon striking the cold boiler surface, forming dense black smoke.

Various means have been devised to secure smokeless combustion. By careful and frequent firing, a thin and uniform bed of fuel may be maintained, from which very little smoke will be given off. Or, by the use of steam-jets or other similar devices, the gases may be violently stirred up over the fire, securing complete intermixture and combustion.

Another way to solve the problem is to place the grate farther away from the boiler and by the use of baffle walls or similar means produce cross currents in the furnace which will bring about the desired commingling of the gases. With most of the mechanical stokers on the market use is made of this arrangement to secure smokeless combustion. It is usually necessary or advisable to place the furnace out in front of instead of under the end of the boiler.

In the furnace illustrated herewith, use is made of a further expedient to prevent the formation of smoke. The furnace is so built that the gases from the freshly fired coal must pass through a bed of incandescent coke, which brings about a thorough intermixture of the gases and ensures complete combustion.



"CROSS DRAFT" FURNACE APPLIED TO A HORIZONTAL TUBULAR BOILER.
Smokeless Combustion Co., New York city, Makers.

This form of furnace may be used with either automatic or hand firing. The one illustrated is of the latter type. The portion of the grate A is similar to the ordinary grate, except that it is inclined to the horizontal. There are two rocking grate-bars B operated by the lever L, for the purpose of assisting the coal and coke to slide down the incline. Finally there is the coking grate C, which is so arranged that it may be dumped by the lever M, to free it of clinkers or other material.

The fuel is heaped up in the furnace so that the lower corner of the fire-brick arch D is covered at all times. When the furnace is in operation the grate B is covered by incandescent coke or coal partly coked, and the space between C and D is filled by incandescent coke. The top of the fuel bed is composed of raw coal.

Air is admitted under the grate from the ash-pit E. It also comes in over the fuel bed through the tuyers T. The draft to the latter is regulated by the damper F. The fire-door G is kept tightly closed. It is evident that the draft from the tuyers will carry all distilled gases down through the fuel bed. It will also serve to keep the upper cover of the furnace cool.

Two furnaces of this type have been installed at the factory of Messrs. Hills Bros., on Irving St., near Van Brunt St., Brooklyn, N. Y., where they are in daily operation alongside of two ordinary furnaces with flat grates. The improved grates are burning Westmoreland gas coal, while anthracite is used in the other furnaces to comply with the city smoke ordinances. The plant has been examined by a member of the staff of this journal and less smoke was seen escaping from the new grate using soft coal than from the old grates burning hard coal. The boilers are 72 ins. × 18 ft. in dimensions, and of the horizontal return tubular pattern.

The boilers and furnaces were tested, May 9, 1900, by Mr. E. M. Hugentobler, Engineer for the manufacturers of the furnaces, with the following results:

Heating surface of boiler		1,800 sq. ft.
Area of combustion under arch		8¼ "
Of coking grate		19½ "
Coal used		Ocean Westmoreland gas coal.
Analysis:	Water	1.326%
	Volatile matter	35.294%
	Fixed carbon	58.955%
	Sulphur	0.655%
	Ash	3.770%
	Total	100.000%
Duration of test		6½ hours.
Steam pressure		87 lbs.
Temperature of feed		71°
Draft in uptake		0.625-in.
Coal consumed		4,300 lbs.
Amount of water evaporated		38,664 "
Steam		Dry.
Horsepower developed		204.07
Factor of evaporation		1.1836
Evaporation (actual) per lb. of fuel		9.206 lbs.
From and at 212° per lb. of fuel		10.896 "
Efficiency (basis of 13,250 B.T.U. per lb. of coal)		79.42%
Nominal manufacturer's rating of boiler		150 HP.
Excess of actual over nominal horsepower		36%
Coal consumed per hr pr sq.ft. of combustion area under the arch		70.95 lbs.

For the material relating to the "Cross Draft" furnace used in preparing this article we are indebted to the manufacturers, The Smokeless Combustion Co., of No. 1 Broadway, New York city, and particularly to Messrs. F. L. Bunton and John J. Cavagnard of that company.

THE EXPORTS OF MANUFACTURED ARTICLES and the imports of manufacturers' materials by the United States for the eight months ending Aug. 1, 1900, as given by a recent report from the Treasury Bureau of Statistics are as follows:

Imports.	
Hides and skins	$36,961,011
Chemicals and drugs	35,583,840
Silk, raw	24,615,716
India rubber, crude	19,938,630
Fibers	19,771,035
Wool	15,800,909
Tin in bars	13,126,739
Tobacco, leaf	9,780,411
Cotton, raw	5,307,976
Furs	4,767,077
Wood	9,439,192
Exports.	
Iron and steel	$87,174,389
Oils, mineral, refined	45,635,600
Copper and manufactures of	41,830,330
Leather and manufactures of	17,697,762
Cotton manufactures	15,293,167
Agricultural implements	13,854,774
Chemicals	9,188,120
Wood manufactures	7,899,857
Scientific instruments	4,171,561
Paper and manufactures of	4,503,766
Tobacco manufactures	4,033,145
Cycles	2,517,717

AN ELECTRIC LOCOMOTIVE of rather novel design is illustrated in the London "Engineer" of Sept. 28. It was built by La Societe Suisse, of Winterthur, for the Fourviere et Ouest-Lyonnais Ry., of Lyons, France, and is intended for working on a rack railway, upon which it must haul 28 tons up an incline of 1 in 5.2 at a minimum speed of five miles per hour. The rack is on the Abt system. Current is supplied at 500 volts to a 150-HP. motor running at 700 revolutions per minute. The motor, by means of two pinions and two spur-wheels on two countershafts, acts on the two axles of the rack wheels. When running on the level the running wheels are driven direct by two 25-HP. motors. On the rack portion of the road all three motors are used. The two motors for the carrying wheels are of the usual four-pole series-wound type. The principal motor is shunt wound. When descending a grade it acts as a dynamo, the current generated being returned to the line. By the use of this device the car will run down a varying incline with nearly constant speed. The locomotive is fitted with very powerful brakes. There are two independent screw brakes which act on the toothed driving wheels, a similar brake on the carrying wheels, and, lastly, an automatic brake which is thrown into action whenever the speed exceeds a certain value or the current is cut off.

THE SURVEY OF THE UNITED STATES AND MEXICAN BOUNDARY.

In 1882, a convention was made between the United States and Mexico, which provided for a survey to relocate the frontier line, but the commissioners in charge of this work were not appointed until the end of 1891. From the commencement of field work in February, 1892, until its close in October, 1893, Mr. J. L. Van Ornum, Assoc. M. Am. Soc. C. E., assistant engineer, was in charge of the topographic party which operated between the Rio Grande and the Colorado rivers. From January to September, 1893, a second topographic party, under the charge of Mr. E. L. Ingram, Assoc. M. Am. Soc. C. E., assistant engineer, operated between the Colorado River and the Pacific Ocean. The American commissioners consisted of Col. J. W. Barlow, U. S. Engineers; Mr. A. T. Mosman, M. Am. Soc. C. E., U. S. Coast and Geodetic Survey; and Capt. D. D. Gaillard, U. S. Engineers. Their report, dated November 1896, has recently been issued, and from it we take some particulars of the survey work.

For measuring the distance along the boundary line the stadia system was adopted, as it is cheap and rapid, is carried on under the eye of an instrument man (who is presumably of a high order of intelligence), and gives heights and angles. Experience on this survey showed that the stadia lines over mountains, hills and canyons were more accurate than the chain lines on level plains and wide valleys. Astronomical observations for latitude, longitude and azimuth at or near the fixed extremities of each of the six sections of the boundary served the double purpose of locating these points and of checking the measured stadia distances between them. These measurements were also checked in several places by triangulation.

That there should be no question as to the relative accuracy or adaptability of chain and stadia measurements, it was decided to measure the entire distance of 118 miles of level country along the boundary on parallel 31° 47' by both systems. The distance was also determined by triangulation, and showed an error of 1 in 1,116 for the stadia and 1 in 1,384 for the chain. From this it might at first appear that over country of this character the chain is the more accurate. This was not actually the case, however, for during the measurement the stadia six times detected the dropping or addition of a chain length of 20 meters. These errors would have escaped notice if the distances had not been compared every night, and remeasurements made whenever serious discrepancies were discovered.

The measured distances along the boundary were used as bases in the topographic work. Locations were made principally by stadia, but in some cases by the method of intersections. Datum points for heights were given by a careful line of levels carried along the boundary from the Rio Grande to the Pacific. Occasionally the topography was filled in from located points by aid of the prismatic compass, hand level and sketching. All heights, except those on the line of levels were obtained by reading the vertical angles of the points located. For a time, aneroid barometers were tried for obtaining heights, and the results were in each case checked by comparison with the line of levels. Great care was used and every precaution was taken, but the results obtained by the use of these barometers were found to be too unreliable, and their unavoidable errors too great, to admit of their use on work where contour intervals were fixed at 20 meters.

In the whole work of the American and Mexican surveys, 256 distances, averaging 4,235.7 meters each, were compared, and remeasurements were made wherever serious discrepancies were shown. These disclosed three cases of errors in the United States measurements. Two of the errors were about 100 meters each, due probably to errors in rod readings; the other was about 30 meters, due probably to a clerical error in recording. As the total number of sights was 5,059, and as two exactly equal and opposite errors could hardly have occurred, when but three errors in all were found, it may be assumed that 3 in 5,059 gives a fair idea of the probability of an accidental error of any considerable magnitude, where the observers are intelligent, careful and conscientious, keep their own notes, and take foresights and backsights at each station. Four observers were engaged in measuring the distances along the boundary line proper, and three of them had an error each. These three errors aggregated 247.46 meters in 1,084,435 meters, or 1 in 4,366. It is stated that this matter has been discussed in detail because it has seldom, if ever before, been possible to thus check work done on so extensive a scale and thereby to determine (even approximately) the effect of errors, the frequency of the probable recurrence of which is almost wholly unknown.

A line of levels which, with its connections, aggregated 732 miles, was carried along the boundary from the Rio Grande to the Pacific Ocean, and connected at El Paso and Yuma with bench marks of the Southern Pacific Ry., and at San Diego with a bench mark established by the U. S. Coast and Geodetic Survey. Great care was taken in running this line. The rods were held on iron pins driven firmly in the ground; equal foresights and backsights were taken, and at each setting of the instrument both the backsight and foresight were read until two values of each were obtained which did not differ more than 0.001 meter, the rod having been unclamped and reset after each reading. The mean of these two values were taken as the true reading. The "boiling" of the air generally caused leveling to be suspended from about 10 a. m. to 3 p. m., thus rendering the progress of the work necessarily somewhat slow. An idea of the rough character of the country can be formed from the fact that the average length of sights for the entire line of levels was but 61 meters. The line was carried around difficult mountains, a transit profile being taken over the mountains.

The transits were of the usual description, manufactured by F. E. Brandis, Sons & Co., of New York, both having 18-in. telescopes magnifying about 30 diameters. The level rods were the New York form, with metric divisions, Gurley's rod levels being used for securing a vertical position of the rod. The stadia rods were designed by the engineers, the face being divided into decimeters and centimeters, as shown in the accompanying cut. The distinctive features of the rod are (1) the diamond form of decimeter division; (2) the entire coloring on one side of the face for long distance readings, while at the other side they are divided into centimeters for short distance readings; (3) the red centimeter divisions to distinguish every half-meter; and (4) the red figures and diamonds, and the changing of the centimeter divisions to the opposite side of the face of the rod to aid in distinguishing the meters. Mr. Van Ornum states that this form of marking was adopted because of the simplicity, while it furnished the distinctive characteristics above noted to aid in readily reading the intervals. The 20 months of field service proves its efficiency. Under fairly favorable conditions, the centimeter divisions could be distinguished at a distance of 250 meters, and spaced by the observer's eye into millimeter readings. In secondary sights the decimeter divisions could be observed at a distance of 600 to 700 meters, and spaced by eye into centimeters. While these long and accurate readings indicate the efficiency of the rod, the clearness of the atmosphere also aided in securing this result. The rods were 4½ meters long, 1 decimeter wide, 20 millimeters thick at the middle, tapering to 15 millimeters at the ends. The foot was shod with band iron. For reconnoissances and for aiding the work of sketching, etc., a prismatic azimuth compass and a Locke hand level were occasionally used.

Stadia Rod for United States and Mexico Boundary Survey.

The vibration or "boiling" of the atmosphere occurs to a remarkable extent in the arid regions of the southwest, and was a subject of study on this survey by Mr. John F. Hayford, assistant astronomer, Mr. J. L. Van Ornum and Mr. E. L. Ingram, assistant engineers, and Mr. L. S. Smith, transitman. The number of vibrations during consecutive minutes was very variable, being in some cases three times as great as in others, and the most rapid vibrations occurring in the intervals when the breeze ceased. When a steady breeze was blowing, objects whose form was distorted and irregular from the atmospheric vibration always suffered more distortion on the leeward side than on the windward side, and their outline appeared actually to be blown with the wind like the flame of a candle. The lateral component of the vibration was in general of less amplitude than the vertical component, and gave to the rod a sinuous appearance and a wave-like movement always from the bottom towards the top. It was also observed that this component of the vibration was always greater at the bottom than at the top of the rod. The lateral component of the vibration affects the accuracy of stadia work, as regards azimuth, to a greater extent than as regards distance. The vertical component of the vibration was of a compound character, consisting of a primary vibration upon which was superimposed a secondary vibration more rapid but of smaller amplitude.

Atmospheric vibration was found to increase rapidly with length of sight, with difference of temperature between the air and the earth, with the brightness of the sun, and with the absence of vegetation. While the general effect of this vibration is to decrease the accuracy of a single sight, yet errors due to this cause are probably compensatory, balancing one another on an extended survey. So far as atmospheric vibration alone was concerned, it was the general rule to continue work whenever the amplitude of the vertical component of this vibration appeared less than 1 centimeter at a distance of 200 meters, at which distance this vibration often reached 1½ and sometimes even 2 centimeters. When wind alone was the disturbing element, work was continued as long as the stadia men were able to hold the rod up against it. The work was prosecuted under these adverse conditions because the great difficulty and expense of procuring water and supplies rendered it imperative that the work should proceed as rapidly as possible, even at a sacrifice in point of accuracy. Appended to the report is a special report upon this matter by Mr. L. S. Smith.

Under the treaties of 1848 and 1853, the boundary was marked by monuments of stone and iron, but many of these had become almost obliterated, and intervals of 10 to 100 miles existed between authentic marks. On the new survey, the monuments were also of stone and iron and not more than 8,000 meters apart. The stone monuments are in the form of obelisks, the shaft being 10 ft. high, 4 ft. square at the base and 2 ft. at the top, built on a foundation 5 ft. square and rising 6 ins. above the ground. On top was a pyramidal cap 12 ins. high. Where only boulders were obtainable, the surface of the monument was covered with Portland cement plaster. New iron inscription plates were put on, in addition to those of the old monuments. The iron monuments are also obelisks, 6 ft. 6 ins. high, 12 ins. square at the base and 9 ins. at the top. They were bolted to the natural rock or to concrete bases 3 ft. square and 2 ft. thick. Those for use on parts of the line which could be reached by wagons were cast solid, the others were sectional. The weight in each case was 800 lbs., and the metal was 2 centimeters thick. Inscriptions in English and Spanish were placed upon the north and south sides respectively, and sockets for a flagstaff on the west side. Two kinds of sectional monuments were used. The first consisted of a base, a cap and four side pieces. These plates were rather long for transportation by pack mule, and the design was changed to consist of a base, a cap, and five horizontal sections for the shaft, each section being 14 ins. high with rabbeted joints. These were held together by a 1-in. vertical bar, the nut of which was concealed by the cap, which was riveted to the top section of the shaft. The castings were made by the Foundry & Machine Co., of El Paso, Tex., and cost about $40 each, complete and ready for shipment. The transportation and erection, and the concrete bases brought the total cost to about $150 each. The average cost of the stone monuments was about the same.

GARBAGE DISPOSAL WORKS, SYRACUSE, N. Y.

(With two-page plate.)

Garbage reduction works on the improved Holthaus system were put in operation at Syracuse, N. Y., in the summer of 1898. For the first two or three months the plant was run by Cyrus Currier & Sons, of Newark, N. J., who constructed the works for the Syracuse Reduction Co. The plant was visited on Oct. 4, 1898, and on Sept. 9, 1899, by a member of the editorial staff of this journal. On both occasions Mr. Emil Holthaus, the inventor of the system, was present, and extended courtesies to our representative. On the occasion of the latter visit Mr. Holthaus was acting as Superintendent of the Syracuse Reduction and Manufacturing Co., which was then using the tankage for making commercial fertilizers of different grades. Most of the information obtained during the last visit was given by Mr. Wm. H. Pratt, who was then in charge of the reduction works proper (excluding the fertilizer adjunct), as a representative of Cyrus Currier & Sons. The manufacture of merchantable fertilizers was begun on Aug. 28, 1899. Several grades are made. The large agricultural district in the vicinity of Syracuse, it would seem, makes this a favorable locality, if there be such, for converting the tankage into fertilizers, instead of selling it to fertilizer manufacturers, the only question being whether the work can be carried out profitably on so small a scale. Reports from the plant during the summer of 1900 stated that it was paying well. It was stated in September, 1899, that the average daily amount of green garbage treated was 30 tons, the capacity of the plant being 50 tons in 24 hours.

The reduction works are located about three miles from the city hall. The city collects the garbage in heavy, covered wooden barrels (old oil barrels, apparently) and delivers it to the works. Here the barrels are emptied into small cars, which are lifted two stories to a floor on a level with the top of the digesters. The cars hold about one ton each. They have steel hopper bodies, so mounted at the ends that they may be dumped by tipping sideways, and may be adjusted to any position, normal, tipped half way, or clear over. The car bodies are mounted on four-wheeled trucks, and run from the top of the elevator over a track on the feeding floor to a movable hopper, which can be adjusted to feed any one of the digesters.

Figs. 1 and 2 give a fair general idea of the works, although the plan was designed primarily to show the arrangement of the piping in the lower story, while Fig. 2 is only a sketch section, not correct in all details. Most of the details of importance, however, are shown by the other illustrations.

There are four digesters, or boiling tanks, shown by Fig. 3, each 5 × 14 ft., made from ¾-in. steel plates. The digesters need to be made of heavy material on account of corrosion due to acids and moisture. Cast iron resists this action better than steel, but is less reliable in other respects. Most of the valves used for the garbage machinery are of cast steel. When the digesters are full, the covers are bolted down and the garbage is cooked with steam under about 60 lbs. pressure. After cooking, the water and grease are first drained out, then a 24-in. horizontal gate valve is opened and the cooked garbage is dumped through a hopper into a hydraulic press, the location of which is shown by Fig. 2, and the details of the press cylinder and press curb by Figs. 4 and 5. The pressure employed is 2,000 lbs. per sq. in. The press has a false bottom, in the form of a horizontal slide valve, or plate, operated by a chain and sprocket wheel.

On opening the valve, or false bottom, of the press, the pressed garbage falls into the drier, Figs. 6 and 7, directly beneath. The drier is about 7 × 14 ft., steam jacketed, with a revolving pipe coil. The inner shell of the drier is made of 5/8-in. steel plates. The outer shell is made of 7-16-in. steel plates, the steam space between being 2½ ins. There are no stay bolts, it having been found that the leakage due to these gave more trouble than the good they did.

After drying, two doors in the bottom of the drier are opened by means of a worm and segmental wheel, Fig. 8, and the tankage falls into horizontal pan conveyors emptying into a bucket elevator, which lifts the tankage to a revolving screen. This is the first time the garbage is exposed to the air after being placed in the digesters. The screen rejects certain foreign substances, such as the remains of tin cans, and separates the balance into tankage and tailings. The available tailings are ground in a mill, and then added to the tankage.

The water and grease from the digesters and the hydraulic press are lifted to three separating tanks, shown at the left in Fig. 1. Here the grease is removed by an adjustable skimmer, and passes to a scrubber, or grease tank, as it is called in Fig. 9, after which it is barreled.

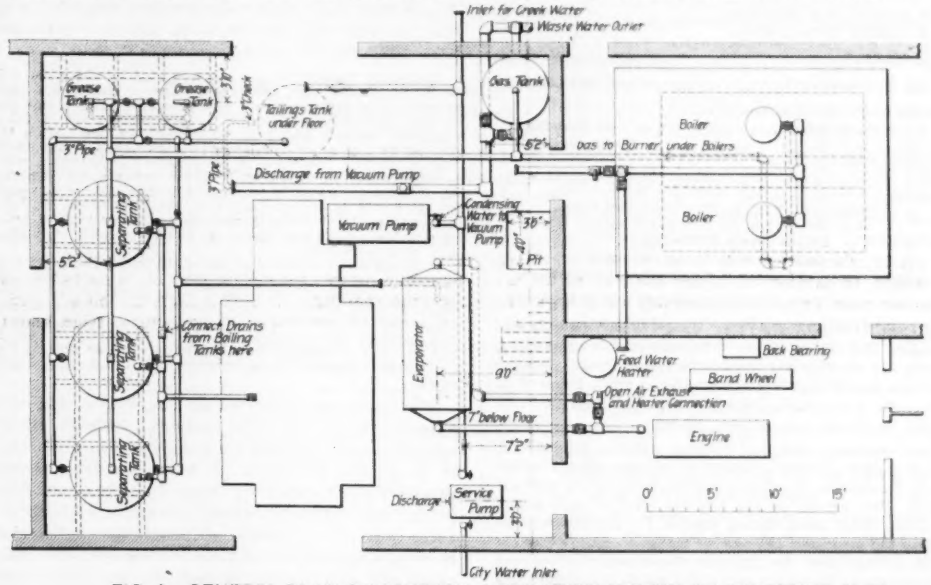


FIG. 1.—GENERAL PLAN OF GARBAGE REDUCTION WORKS AT SYRACUSE, N. Y.

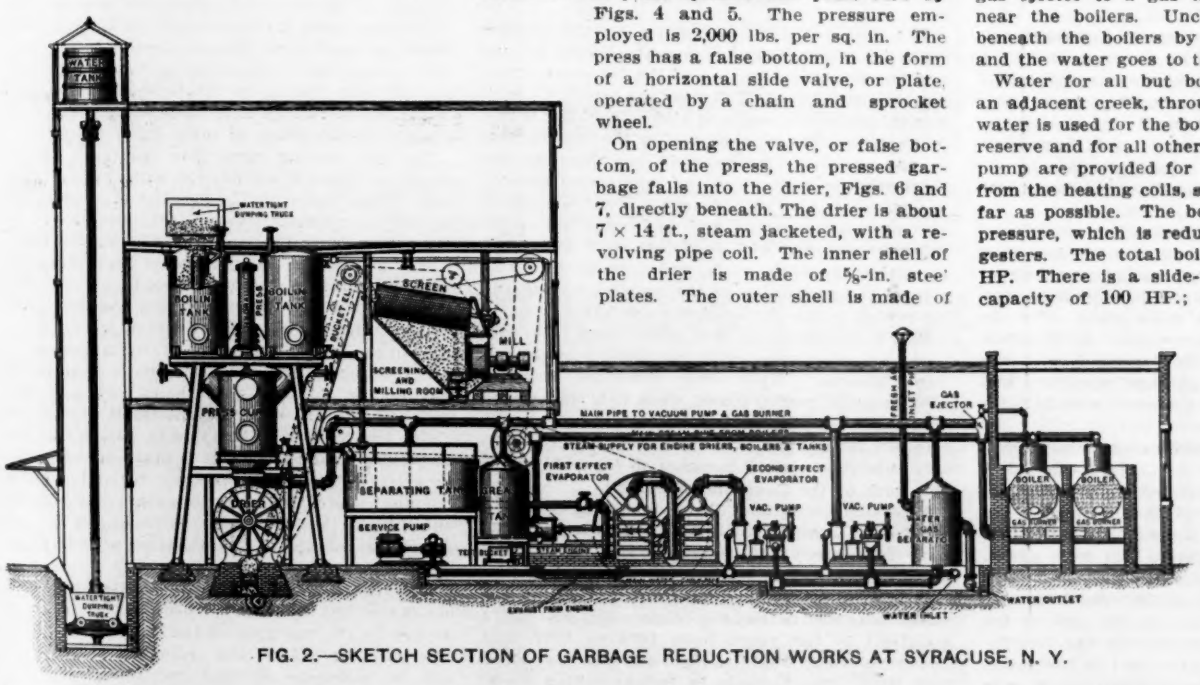


FIG. 2.—SKETCH SECTION OF GARBAGE REDUCTION WORKS AT SYRACUSE, N. Y.

The water from the grease separating tanks goes to evaporators in which exhaust steam is used. The "stick" goes to the drier, where it is mixed with tankage.

The gases and vapors from the digesters, driers and evaporators are drawn off by means of a gas ejector to a gas tank, or scrubber, located near the boilers. Uncondensed gases are sent beneath the boilers by means of a gas ejector, and the water goes to the sewer.

Water for all but boiler uses is drawn from an adjacent creek, through a settling tank. City water is used for the boilers, and is available as a reserve and for all other purposes. A hot well and pump are provided for utilizing the condensation from the heating coils, steam shell and the like, so far as possible. The boilers carry about 100 lbs. pressure, which is reduced to 60 lbs. for the digesters. The total boiler capacity is about 180 HP. There is a slide-valve engine of a normal capacity of 100 HP.; also electric lighting and complete fire protection systems, including automatic sprinkling apparatus.

The mechanical details of the plant appear to have been worked out with unusual care. Besides the devices named for operating gates, Hyatt roller bearings are used in some portions of the plant, particularly on the large pipe coil in the drier.

The plant is covered by 18 patents in the name of Cyrus C. Currier. It is an improvement on the system installed at Bridgeport, Conn., a few years ago.

Mr. John Dunfee, of Syracuse, is President of the Syracuse Reduction Co. Mr. Percy B. Taylor was mechanical engineer for Cyrus Currier & Sons during the design and construction of the works, and we are indebted to both Mr. Taylor and the above-named firm for information and blue prints used in preparing this article.

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WM. KENT, E. E. R. TRATMAN, } ASSOCIATE
M. N. BAKER, CHAS. S. HILL, } EDITORS.

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A correspondent in our "Notes and Queries" column, in the issue of Sept. 13, inquired whether a concrete bridge had both substructure and superstructure, or whether the whole thing, arch, abutments, underwater work and all was superstructure. Ordinarily such a query would have little interest; but in the case that gave rise to the query a legal decision of considerable moment was involved.

The Ohio law provides that when a highway bridge is to be built by county commissioners, complete plans and specifications for the substructure must be prepared and competitive bids must be asked for carrying out these plans. For the superstructure the same course may be followed; or, instead, bidders may be furnished with the length and width of the proposed structure and invited to submit their own designs with bids for their construction.

The Commissioners of Muskingum county, Ohio, desired to build a bridge to replace the old Y bridge at Zanesville, illustrated in our issue of Jan. 25 last, and employed the Osborn Co. of Cleveland to make general plans and specifications for the structure. Upon these, bids were advertised for, and bidders were asked to submit their own plans. The specifications included both masonry and metal structures. In the case of the former, the entire construction from the foundation line upward was included; but in the specifications for the metal superstructure it was stated that contracts for the substructure would be awarded separately, to conform with the law.

The work was advertised on May 8, and when the bids were opened on June 14, no less than 67 plans or designs were submitted by 17 different bidders, the prices ranging from $60,000 to $240,000. After canvassing the bids, the contract was awarded to the Berlin Iron Bridge Co., the design selected being a concrete-steel arch on the Thacher system, and the price being $188,000.

Suit was brought by one of the defeated bidders to set aside the award, on the ground that separate plans for the substructure and a separate contract for it were not made as required by law. The decision in the case, therefore, turned upon the question whether a monolithic concrete bridge had a substructure or not. The case was tried in the local court and was sharply contested, some four days being spent in the presentation of evidence and arguments. The court's decision was in favor of the defence, the judge ruling that no division into substructure and superstructure was feasible in the present case, and hence that the Commissioners had complied with the law and their award of the contract was legal. The following is quoted from his decision:

> Evidently the legislature contemplated by the term substructure, a divisible, separate portion of the bridge, to be erected by a different kind of mechanical labor from that of the superstructure, a part of the bridge for which a separate contract could be let, something that, when impaired by age or the action of the elements, could be replaced without interference with the superstructure, such substructures as those with which we are all familiar. The bridge proposed to be erected is incapable of any such division. It is impracticable, if not impossible, to let a separate contract for such part as lies below the springing line of the arches and that part lying above the springing line of the arches. . . .
>
> It seems clear to me that the statutes by the term substructure, import a structure capable of separation from the superstructure, a distinct and severable structure. Such a thing is not in this case, in my judgment, and, therefore, the provisions of the law regarding separate contract for the substructure do not apply. If that be not so, then I suggest it is impossible, under the laws of our state, for the commissioners to build a concrete bridge.

The case was appealed by the losing side to a higher court; but the judge's decision above quoted seems marked by common-sense, whether it is finally sustained or not. As an abstract proposition, it may be argued that a concrete bridge has both a substructure and a superstructure; but as a matter of practical engineering there are strong reasons for letting both the substructure and superstructure to one contractor and having them built as a single piece of work. To pursue a contrary course would be against the public interests, and, even though the letter of the law might be thus observed, its spirit would certainly be transgressed.

STATISTICS OF THE RAILWAYS OF THE UNITED STATES IN 1899.

The two principal authorities on the railway statistics of the United States are Poor's Manual and the Statistical Bureau of the Interstate Commerce Commission. This year the two issue their annual statistical volumes almost simultaneously, so nearly so that we shall review the two together in one article. Of course, in completeness and thoroughness there can be no comparison between the work of the two concerns. The Government bureau is a permanent and well-organized establishment supplied with sufficient staff and funds to enable thorough work, and with authority to compel the production of the necessary facts and figures on which the statistics are based.

Poor's statistics, on the other hand, are prepared as a side issue in the compilation of the annual "Manual." They cover, therefore, little except financial matters, and when it is understood that their compilation is a matter of private enterprise, involving no direct return, it is remarkable that they should compare so favorably with the work of the Government bureau.

A particular merit of Poor's statistics is that a great deal is presented in very small space. We have reproduced one comprehensive table from Poor's introduction, and present it herewith.

It is interesting to notice from a study of this table how nearly railway expansion was at a standstill in the years from 1894 to 1897, and how remarkably rapid the growth has been since that time. The increase in freight rolling stock, for example, from 1894 to 1897 was only about 6,000 cars; whereas the increase from 1897 to 1899 was nearly 100,000 cars. The tons of freight moved was little greater in 1897 than in 1893, but 1899 shows an increase of nearly one-fourth over 1897. Passenger traffic remains nearly stationary, the growth year by year being largely offset by the loss of suburban travel to electric lines. Earnings, both gross and net, show a like ratio of increase to the freight traffic, in the lean times and fat times respectively. The great increase in dividend payments, however, indicates that the railways have devoted a large portion of their increased revenues to improving their property and getting in position to handle traffic more economically instead of dividing profits among their security holders without regard to the future. One notable form of permanent way improvement which in the 80's necessitated heavy contributions from the revenue was the replacement of iron rails with steel. In 1880 there were 82,000 miles of iron rails in United States railway tracks and only 33,000 miles of steel rails. In 1890 half the iron rails had disappeared and the steel rails had increased to 167,000 miles. In 1899, with 250,000 miles of railway track in all, 230,000 miles are laid with steel and only 20,000 miles of iron rails are left. The surprising thing is that there should still remain so much of the latter. Probably they are mostly in place on little used sidings where they answer the purpose as well as a better material.

Doubtless the most common question asked in the field of railway statistics is the question of mileage. How many miles of railway are there in the United States? On this matter the two authorities agree very closely. The Interstate Commerce figures for June 30, 1899, are 189,297 miles. Poor's figures for Dec. 30, 1899, are 190,833 miles. The difference may easily be accounted for by construction during the six months. In fact, Poor records 3,981 miles built in the calendar year 1899, which just about covers it. That these figures compares so closely, indeed, indicates the probability that Poor has endeavored to conform to the standards adopted by the Interstate Commerce bureau. Otherwise a much wider discrepancy between the figures would be expected.

It would surprise many, we presume, to know how difficult is the collection of exact figures of railway mileage. In nearly all cases in these statistics electric railways are excluded; yet branches of steam railway lines operated by electric motive power are included; and with the rapid increase in cross-country electric railways carrying both freight and passengers, it will become necessary to include a considerable mileage of electric roads in these statistics. Again, it is most difficult to draw the line between a spur or siding and actual main track mileage. As there is about 50,000 miles of yard track and siding in the country, or more than one-fourth as much as the mileage of main tracks, it will be seen that a slight variation in rulings here may make a large difference in the totals of main track mileage.

The lines having more than one track are still small in extent in comparison with the total mileage. There are only 11,546 miles of second track in the United States, over 7,000 miles of which is located in New England and the Middle States. There has been a large increase of double-track, however, during the past decade on the roads radiating westward from Chicago, and this section now has over 2,000 miles of second track.

Turning to the statistics of rolling stock, we find the total number of locomotives given as 36,703 in the Interstate statistics, whereas Poor gives 37,245. In cars the Interstate reports also show smaller totals, but this is due, we believe, to the fact that no account is taken of cars owned by private shippers, refrigerator car and stock car companies, etc. This is an important omission, and one which the Interstate Commission would doubtless rectify if granted the necessary authority.

This report of the Interstate statistician is notable as the first to be made since the practical completion by the railways of the equipment of their cars with air brakes and automatic couplers. It will be remembered that the Interstate Commerce Commission advanced the date at which the national safety appliance law should take effect, and it finally became operative on Aug. 1 last. The figures in this report are over a year earlier than this. Briefly stated, they show a total of 1,295,510 freight cars in service, of which 730,670 are fitted with air brakes and 1,067,338 with automatic couplers. As the law does not require all freight cars to be equipped with air brakes, but only enough in each train to enable it to be con-

trolled from the engine, it will be seen that the period from the date of these figures to the taking effect of the law was ample to enable the railways to complete their equipment.

In the table showing the kind of brakes in service it is of interest to note that the Westinghouse is credited with 754,157, the New York with 51,393, and the Boyden with 1,014.

The list of different makes of coupler is a very long one; but the figures show that the Gould Co. and the McConway & Torley Co. have applied over half the couplers in service, while a half-dozen other makes account for a good share of the remainder. The following table gives the number credited to each make of coupler of which more than 5,000 are in use:

Janney	286,491	California	15,176
Gould	233,527	Little Giant	14,326
Chicago	91,629	Lone Star	13,550
Buckeye	84,894	Shickle, Harrison & Howard	12,595
Tower	73,789	Williams	10,196
Trojan	71,154	Smillie	7,812
Unclassified	44,881	Thurmond	7,593
Hein	36,307	Washburn	5,804
Standard	34,211	Pooley	5,186
American	22,837		
Missouri Pacific	22,009		

The Interstate statistics of number of employees show a total in 1899 of 928,924, a far larger number than in any year on record. In 1893 the total was 873,602, but the number was reduced by more than 100,000 in the following year, and not till 1898 were the figures of 1893 equalled. Of this huge army, constituting, with their families, probably nearly 4 per cent. of the total population of the country, only about 9,100, or less than 1%, are ranked as officers. In other words, each officer averages over 100 men under his control. For this amount of responsibility their compensation is very low, averaging, for the United States as a whole, but $7.60 per day, and this average includes, of course, the large salaries paid to Presidents, General Managers and other officers holding the places of highest responsibility. The whole body of officers are divided into two classes, designated as "General Officers" and "Other Officers," and nearly equal in number. The average compensation of the former class is $10.03 a day, and of the latter $5.18 a day. These average daily payments, it is to be noted, are based, not on yearly salaries with 365 days per year, but on actual days worked. Assuming 300 days per year to be a fair average, this represents annual salaries of about $3,000 for general officers and $1,550 for other officers.

Among the employees, enginemen and conductors receive much the highest wages, the former averaging $3.72 per day and the latter $3.13. General office clerks, firemen, machinists and carpenters average over $2 per day, but all other classes of employees rank below this, trackmen standing at the foot of the list with average wages of $1.18 per day. Notwithstanding this low average wage, their number is so much in excess of any other class of employees that their wages amount to a larger total than the amount paid to any other class of railway labor.

The total operating expenses of United States railways in 1899 were $856,969,000, and of this sum $522,968,000 went to pay the wages of employees. Of every ten dollars paid out by the railways for operating expenses, six dollars went to pay wages and salaries of employees.

It may be of interest to follow the matter a little further and see how large a proportion of railway earnings goes to pay the wages of labor as compared with the proportion going to pay interest or dividends to the holders of railway securities. In the following table the figures are given to even millions only:

Total earnings from operation		$1,313,000,000
Paid in salaries and wages	$523,000,000	
Other operating expenses	334,000,000	
Interest on bonds and other debts	258,000,000	
Dividends on stock	111,000,000	
Taxes	44,000,000	
Permanent improvements	22,000,000	
Other payments	21,000,000	
		$1,313,000,000

It must be remembered in considering the above that a very large proportion of the "other operating expenses" and of the expenditure on permanent improvements actually goes to pay wages. In the purchase of rolling stock, for example, the bulk of the purchase money goes to pay wages of workmen in locomotive and car shops just as would be the case if the rolling stock were built in the company's own shops. Making allowance for this, it seems probable that not less than 60% of the total receipts of railway companies is paid out directly as wages to labor.

It is probably true that in few occupations are such large responsibilities carried, such great risks involved and such arduous labor performed for so small a compensation, as is the case in all grades of the railway service. Yet it is entirely evident from the above figures that the railway employee is getting his full share of the railway earnings. If he is to receive higher pay it must be through larger earnings of the companies, or, in other words, larger payments by the public in the way of fares and freight charges.

Of the total payments to those who have invested their capital in the country's railways $258,000,000 is interest on bonds and other debts, and is at an average rate of only 4.6%. It will hardly be disputed that the bonds and debts of the railways represent money actually invested. As a matter of fact they represent in many cases much more money than is now receiving an income from the property. Even at the present time, with all the prosperity that 1899 brought to the railways, 10 per cent. of all the outstanding railway bonds received no interest in that year.

Turning now to the actual owners of the roads, the stockholders, we see that they received $111,000,000 in dividends in 1899, or about one dollar for every six or seven which went to pay wages to labor.

In the introduction to "Poor's Manual" it is estimated that of the total railway stock outstanding, about $1,250,000,000 is full paid stock. If the holders of this stock are assumed to be entitled to 6% on their investment as an average return, they would receive $75,000,000. Deducting this sum from $111,000,000, the dividends actually paid, we have left $36,000,000 as an outside estimate for the returns made to holders of "watered stock." This is a huge sum, yet it is insignificant in comparison with the total of railway operations. If it were wiped out entirely, it could add only a very trifling percentage to the earnings of railway employees, or deduct a still more insignificant percentage from the payments by the public for railway transportation.

There are abuses in the railway service, undeniably, but when they are all summed up and estimated at their maximum possible value, it is seen that they are insignificant in comparison with the total volume of business done.

Turning now to the public service performed by the railways, we find the total set down as 510,000,000 tons of freight and 523,000,000 passengers. The average haul of a ton of freight, however, is much greater than the length of the average passenger journey being 242.45 miles for the latter and 27.89 miles per passenger. Of the freight tonnage, products of mines provides 51%, products of agriculture and animals 14%, manufactures 13%, forest products 11% and merchandise only 4½%.

The movement toward heavier train loads is well shown in the statistics, the average freight train load in 1899 being 243.52 tons. This is a jump of 17 tons above 1898 and of nearly 40 tons from the figures of 1897, while if we go back to 1890 we find the average freight train load to have

STATISTICS OF RAILWAYS OF THE UNITED STATES, 1892 TO 1899.

(From the Introduction to "Poor's Manual" for 1900.)

	1899	1898	1897	1896	1895	1894	1893	1892
	Miles.	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*
Mileage of Railroads.	187,781.08	184,894.33	183,547.07	181,394.17	179,821.26	178,054.02	175,441.77	171,804.72
2d Track, Sidings, etc.	62,581.72	60,344.54	58,153.69	57,335.77	55,209.80	54,701.16	52,410.89	49,823.81
Total Track	250,362.80	245,238.87	241,700.76	238,729.94	235,031.06	232,755.18	227,852.66	221,628.53
Steel Rails in Track	229,645.54	220,803.87	215,657.83	210,290.46	206,381.05	197,491.43	190,717.71	182,710.76
Iron Rails in Track	20,717.26	24,435.00	26,042.93	28,439.48	28,650.01	35,263.75	37,134.95	38,917.77
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
Locomotives	37,245	36,746	36,410	36,388	36,610	36,304	36,118	34,626
Cars—Passenger	26,194	25,844	25,654	24,940	23,419	23,357	27,179	24,604
Bag., Mail, etc.	8,121	8,049	8,180	7,880	7,891	7,921	7,877	7,830
Freight	1,328,084	1,284,807	1,234,972	1,245,640	1,230,798	1,228,781	1,206,444	1,177,113
Total Revenue Cars	1,362,399	1,318,700	1,268,806	1,278,460	1,265,108	1,263,059	1,241,500	1,209,547
Liabilities:	$	$	$	$	$	$	$	$
Capital Stock	5,742,181,181	5,581,522,858	5,602,934,449	5,373,187,619	5,181,373,599	5,027,604,717	5,021,576,551	4,863,119,073
Bonded Debt	5,644,858,027	5,635,363,594	5,534,432,492	5,461,856,798	5,648,659,436	5,605,775,764	5,510,225,528	5,405,049,969
Unfunded Debt	305,777,858	368,182,584	380,609,705	344,499,969	418,536,623	382,927,834	409,909,043	285,455,287
Current Accounts	377,497,070	383,682,168	397,928,861	389,313,919	429,331,956	438,911,691	381,575,253	417,466,957
Sinking and other Funds	95,013,713	Previous to 1899, included with Profit and Loss.						
Total Liabilities	12,165,327,849	11,968,751,204	11,915,905,507	11,568,858,305	11,677,901,614	11,455,220,006	11,323,286,375	10,971,091,286
Excess of Assets	291,946,163	316,616,498	307,793,194	363,289,063	358,652,751	353,205,967	406,750,426	388,469,733
Total	12,457,274,012	12,285,367,702	12,223,788,701	11,932,147,368	12,036,524,365	11,808,425,973	11,730,036,801	11,359,561,019
Assets:								
Cost of RR. & Equip.	10,254,251,458	10,256,275,585	10,304,221,478	10,079,496,420	9,868,102,973	9,693,141,387	9,373,703,214	9,293,052,143
Other Investments	1,708,507,108	1,594,565,979	1,519,550,500	1,457,656,210	1,683,909,606	1,651,366,198	1,671,841,101	1,600,493,849
Sundry Assets	325,725,460	265,264,972	225,524,124	222,473,770	259,804,963	238,306,300	244,614,098	253,089,497
Current Accounts	168,789,986	169,261,166	174,492,599	162,520,968	294,706,821	225,612,088	239,878,388	212,925,530
Total Assets	12,457,274,012	12,285,367,702	12,223,788,701	11,932,147,368	12,036,524,365	11,808,425,973	11,730,036,801	11,359,561,019
	Miles.	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*
Miles of RR. Operated	186,590.38	184,582.61	181,874.07	180,091.19	179,153.62	176,220.55	173,361.38	170,606.84
Rev. Train Mileage:								
Passenger	355,106,833	344,761,142	342,464,408	337,641,115	326,184,596	325,981,869	338,551,608	323,930,550
Freight	534,391,846	542,824,509	500,326,372	497,948,296	491,410,840	475,789,865	531,340,754	523,831,458
Mixed	20,996,771	17,424,581	15,245,049	15,785,433	15,457,989	15,381,001	17,751,928	17,148,455
Total	910,495,450	905,010,232	858,036,179	850,674,844	833,053,358	817,152,735	887,644,290	864,910,463
Passengers Carried	587,977,301	514,982,288	504,106,525	535,120,756	529,756,259	509,660,216	597,056,539	575,769,678
Passenger Mileage	14,859,541,995	13,672,497,664	12,494,958,009	13,054,840,243	12,609,082,531	13,600,531,635	14,979,847,456	13,594,343,804
Tons Freight Moved	975,789,941	912,973,853	788,385,448	773,868,716	755,799,863	674,714,747	767,464,480	730,605,011
Freight Mileage	136,991,703,110	114,566,173,191	97,842,549,150	93,885,883,634	88,567,770,801	82,219,900,498	90,962,087,290	84,413,197,130
	$	$	$	$	$	$	$	$
Traffic Earn'gs—Pass.	297,559,712	272,589,591	253,557,936	265,313,258	260,229,741	275,352,190	310,442,870	293,557,476
Freight	922,436,314	868,934,526	790,351,939	770,434,013	743,784,451	700,477,409	808,494,668	794,526,509
Miscellaneous	116,100,353	108,044,607	98,966,751	89,894,754	87,681,945	91,113,759	88,168,488	80,952,864
Total	1,336,096,379	1,249,568,724	1,132,866,626	1,125,632,025	1,092,395,437	1,066,943,358	1,207,106,026	1,169,036,840
Net Earnings	447,741,014	389,666,474	342,792,030	333,766,979	323,196,454	317,737,399	358,648,918	352,817,405
Other Receipts	66,138,429	104,536,904	97,631,314	104,934,911	113,768,075	95,158,834	111,166,837	114,428,952
Total Avail. Revenue	513,879,443	494,203,378	440,423,344	437,701,890	436,964,529	413,916,233	469,815,755	467,246,357
Payments:								
Interest on Bonds	208,957,209	237,133,099	234,454,578	243,287,730	239,698,134	234,702,912	227,677,728	229,909,262
Other Interest	6,071,451	5,009,290	5,776,727	8,034,840	8,197,750	7,444,802	7,107,718	6,593,287
Dividends on Stock	88,076,393	94,937,526	83,680,040	81,528,154	81,695,774	83,478,669	94,395,815	93,862,412
Miscellaneous	30,569,447	35,631,060	29,123,068	34,297,635	33,404,887	38,230,068	38,190,641	32,708,646
Rentals—Interest	30,221,704	62,740,145	59,525,937	59,288,517	68,895,966	60,840,237	64,698,368	62,541,445
Dividend	30,955,859	Previous to 1899, not segregated; total amount paid as rentals tabulated and retabulated for each company, thereby causing a fictitious item "receipts from other sources."						
Miscellaneous	20,010,276							
Total Payments	410,862,339	435,561,140	412,560,350	426,386,876	431,871,511	424,686,688	441,970,270	425,615,052
Balance, Surplus or Deficit	*S.* 103,017,104	*S.* 58,642,238	*S.* 27,862,994	*S.* 11,315,014	*S* 5,092,718	*D.*10,770,455	*S.* 27,845,485	*S.* 41,631,275

been but 175 tons. Thus the average paying load of the American freight train has increased nearly 40% in the past decade—a fact worth remembering.

It is this heavier train loading more than anything else which has rendered possible the marvellous drop in rates, which have fallen from an average of 0.941 cts. per ton mile in 1890 to 0.724 cts. in 1899. It is worth noting that with the exception of 1892 the drop in rates has been continuous. The average freight train earnings per mile run have remained nearly stationary, but have on the whole slightly increased, the heavier loading a little more than offsetting the lower receipts per ton mile. Passenger rates have fallen as well as freight rates, though not so rapidly, reaching last year an average per mile of 1.925 cts. Only in 1898 and 1894 has an average rate below 2 cents ever before been reached.

No less than 16 pages of the Interstate report are devoted to statistics of accidents. Notwithstanding all that has been done in the introduction of safety appliances, the list of killed and injured was larger in 1899 than in any previous year, reaching a total of 7,123 killed and 44,620 injured. This increase is not wholly accounted for by the increase in traffic and in number of employees, for computations show that there has been a relative as well as an absolute increase, due probably to the greater crowding of trains and to the fact that in expanding the force of railway employees it has been necessary to take on a ocmparatively large proportion of inexperienced men. Notwithstanding the large proportion of the rolling stock now equipped with automatic couplers and air brakes, the report shows 260 employees killed and 6,765 injured in coupling and uncoupling cars, while 459 were killed and 3,470 injured by falling from trains and engines.

Among passengers, 239 were killed and 3,442 were injured; of these casualties 82 deaths and 1,557 injuries occurred in collisions or derailments. The "deadly grade crossing" caused 672 deaths and 1,070 injuries during the year, nearly all of which, of course, occurred to others than passengers or employees.

It would be interesting to know the expense to the railways due to accidents, but a large part of this expense is placed under the general head of repairs to rolling stock and structures, so that it cannot be separately determined. We note, however, under the head of "Conducting Transportation" that "Loss and Damage" from all causes amounted to $5,976,082; the sum of $7,116,212 was paid for injuries to persons and $1,197,901 was spent in clearing wrecks. Moreover, legal expenses amounted to $5,783,372, a considerable part of which was incurred, probably, in defending damage suits.

"COMBUSTIBLE OXYGEN."

A couple of years ago the efforts of a certain class of promoters were largely devoted to informing the public of the wonderful possibilities of compressed air as the motive power of "auto-trucks" and other vehicles. More recently liquid air has been exploited in a similar manner. The availability of air for "raising the wind," in a financial sense, does not, however, appear to be exhausted. According to a pamphlet issued by the American Heat, Light & Power Co., of No. 27 State St., Boston, capital $1,000,000, it has been discovered that the oxygen of the air is a wonderful fuel, of far higher thermal value than either carbon or hydrogen, which have hitherto been supposed to be the only elementary fuels that can be used for ordinary purposes, such as raising steam and the like. It appears from the statements made in this pamphlet, that if air has mixed with it a very small proportion of either natural gas, finely-divided carbon, or hydrocarbon vapor, the oxygen of the air becomes a fuel capable of developing a larger amount of heat and a much higher temperature than the gas, carbon or vapor themselves would develop when burned in the usual manner. The pamphlet contains a well-written pseudo-scientific essay by Lorin Blodgett, entitled "The Combustion of the Oxygen of the Air Effected by Diffusion of Hydrocarbon Gas." We quote the concluding paragraph of this essay as follows:

> I repeat, therefore, the announcement of a new principle or law of the evolution of heat by combination, namely, that of assuming the first place for oxygen, and of the attainment of the maximum of heat by the diffusion of a minor or secondary combustible throughout the volume of oxygen in air, with the result of a complete and controllable combustion, and the utilization of heat to a far greater degree than is possible by ordinary methods, or by any methods at present in use. This accession of heat being due entirely to the more complete burning of the oxygen, and not to the greater use of the fuels at present recognized as the sources of heat, the cost is reduced to a minimum, and it is limited to the cost of the small proportion of hydrogen and carbon of the gas used, which is preferably made from petroleum, but may be coal gas as made for illuminating purposes.

The practical method adopted to carry out this "new principle" is simply pumping air through crude petroleum. Analyses shows that the gas thus produced contains more than 90% of air. The process of producing the gas is said to be absolutely safe, and "the gas is non-asphyxiating, and superior to any other, either natural or artificial."

That the claims for the gas have been demonstrated experimentally appears from the following statement:

> Exhaustive tests of our apparatus, the process, the gas, its qualities and attributes have been made by practical, scientific and professional men, among whom may be mentioned, a professor of the Massachusetts Institute of Technology, a prominent gas engineer, a well-known mill man from one of our large manufacturing cities, the chief engineer of one of Boston's largest establishments, and many others, whose reports are on file at the office of the company, where they may be inspected.
>
> These tests were of a duration varying from two days to twelve days, during which time the Cambridge plant was surrendered entirely to their control. All obtained extraordinary results, although there was naturally a variation, owing probably to the differing methods of handling an unfamiliar apparatus. With one pound of oil as much as 165 pounds of water were evaporated. This apparently impossible result is simply explained by the principle set forth above, and, as "seeing is believing," we are making practical demonstrations at our plant, to which the public is invited.

We regret that the name of the professor at the Massachusetts Institute of Technology is not given, so that we might obtain from him a detailed account of his tests, but as "the public is invited" we trust that some of our Boston readers who are fond of wonders will visit the office of the company, 67 Brazer Building, 27 State St. and also the "large plant" which it is said may be seen at 87 Main St., Cambridgeport, in practical operation.

The pamphlet contains several half-tone cuts showing views of the apparatus in the works, which remind us very much of a so-called electrical gas process exhibited in New York about two years ago. It disappeared quite suddenly. A visit to an exhibition of this kind is always instructive to students of human nature. It reveals the characteristics of a somewhat rare type of being, the oratorical representative of the alleged inventor, who seems to have a sort of hypnotic influence over another type, not at all rare, the easily-gullible investor, technically known as a "sucker," of whom it has been said that one is born every minute. It is difficult to believe that any sane man would invest in this "combustible oxygen" humbug, which is one of the most transparent that has appeared for some time, but according to a slip enclosed in the pamphlet, signed Frederick Wm. Hill, some people, sane or insane, have already invested in it. The slip says:

> Nearly all of the stock of the American Heat, Light & Power Company is subscribed. If you care to look into the merits of this *extremely* promising investment, please call or open correspondence immediately, as I believe that the opportunity will not remain open many days.

In conclusion it may be remarked that investors should be very careful indeed about accepting the statements in glittering prospectuses to the effect that this or that well-known engineer has tested or approved the device, or such remarks as that above quoted relating to an alleged test by a professor of the Massachusetts Institute of Technology.

As an example of the lengths to which some of these concerns will go in the unauthorized use of names, there lies before us a pamphlet issued by a steam-jet smoke prevention concern, on the first page of which appears the name of a well-known engineer, professor of mechanical engineering at a prominent State university in the west, and the following testimonial:

> "University of ———, Mechanical Engineering Department.
>
> "The official test made by me of this system shows that it is an absolute preventor of smoke, and increases the boiler capacity. Also a fuel saver.
>
> "I can recommend the device to all users of steam."

This sounded so little like the professor whose name was attached thereto, that we were prompted to make personal inquiries of him. He informed us that the quotation was wholly false. He had made a test on the device for the predecessors of the present concern some four or five years ago, and had rendered a carefully-guarded report, containing no such expressions as those attributed to him. For this test and report, by the way, he had never been able to collect any payment. It can be readily understood, therefore, how little avail it would be to attempt to collect damages from the concern for the unauthorized use of his name.

The only real remedy for the attempt by irresponsible parties to make capital through the unauthorized use of the names of reputable engineers, engineering schools or engineering societies, lies in the criminal courts; and their machinery ought to be more freely exerted in this field for the protection of the business community.

LETTERS TO THE EDITOR.

The Engineering Problem at the Southwest Pass.

Sir: The timely papers by Major Wm. Starling, M. Am. Soc. C. E., in your issues of Aug. 23 and of Oct. 4, on the engineering problem at the delta of the Mississippi, have been read with much interest. In view of the great importance of maintaining an ample channel for the commerce of the central West I have taken the liberty of submitting a few remarks thereon. In his first paper, on the results of the parallel curved jetties at South Pass, Major Starling shows that although built originally about 1,000 ft. apart, they were ultimately contracted by spurs and secondary jetties to nearly 600 ft., and that notwithstanding this "over-contraction" there has been a progressive shoaling of the channel with every prospect of its continuance, making the improvement of the bar at the Southwest Pass imperative. In view of this experience, therefor, the author states the serious objections to parallel jetties and concludes:

> If it were necessary to place close and parallel jetties at the mouth, it would no doubt be better to build the east jetty first, and then, under the shelter afforded by it, to dredge out the channel before constructing the west jetty, with such scour as the river, held from spreading out on one side, might offer. But excessive contraction is by all means to be avoided. These reasons have militated strongly against the employment of jetties arranged after the conventional pattern.

He also says dredging "had not been made the principal reliance at the mouth of a great silt-bearing river," and then proceeds to describe the plan proposed by the board of 1899, of which he was a member, and to state the problematical results.

As this plan is described and illustrated in the "Franklin Institute Journal" of July last, it is unnecessary to encumber this paper with a lengthy review, but it would seem to be important to call attention to a few points which the author has not made quite clear and which appear to be based upon "hopes" rather than observed facts.

(1) The use of jetties is virtually abandoned for the creation of a channel, yet they are to be built on the softer portions of the mud flats which the river is constructing and where they will have the least effect upon the ebb currents. They are divergent for a long distance, then suddenly convergent and finally parallel, and 3,000 ft. apart, only just over the crest of the bar. (See Fig. 1.) The plan is well defined by the term "bottle" shaped. The hope is expressed that the maximum velocity will continue to pass through the center of this stretch of variable cross section and that accretions will rapidly form on its flanks, thus filling them up, with the aid of the silt to be pumped into them, until a normal section of about 70,000 sq. ft. is secured. It seems to the writer that the action of tidal rivers does not warrant this conclusion, for it is observed that in wide reaches where the currents expand and velocities are reduced the channel becomes bifurcated and "middle grounds" form, causing the deeper water to seek the banks, but especially is this the case at the upper end of a contracting section where the channels are caused by the reaction of the banks. The result to be expected is a large amount of deposit in the region of the convergent portion of the jetties which will feed the pass through the parallel portions with great quantities of silt.

(2) It is also stated that to build the jetties simultaneously, as was done at South Pass, would partially dam up the pass, diverting the discharge through other openings and causing deterioration. This is undoubtedly correct, so that only one jetty, and that the East one, should be built first until a normal section has been created; but the writer's contention has been that that jetty, as designed, is too remote to guide the currents. It should be of such form and in such position as to maintain the currents and cause a concentration of the major portion of the volume to the channel to be created, allowing the river to construct its own natural levee on the right bank, where it may automatically adjust itself to its requirements and deposit its sediment. By this

means the natural forces of the stream are utilized to the greatest advantage for the creation and maintenance of the channel. This accords precisely with the method pursued by the river, for the author very truly says in describing the bar, "The central thread of current has gradually pushed its way forward and built up its banks *by lateral outflow* on either side." "These banks concentrate the waters and give the current greater power, etc." Thus the lateral movement of the silt is recognized, but

Fig. 1.—Plan Proposed by Board of Engineers of 1899.

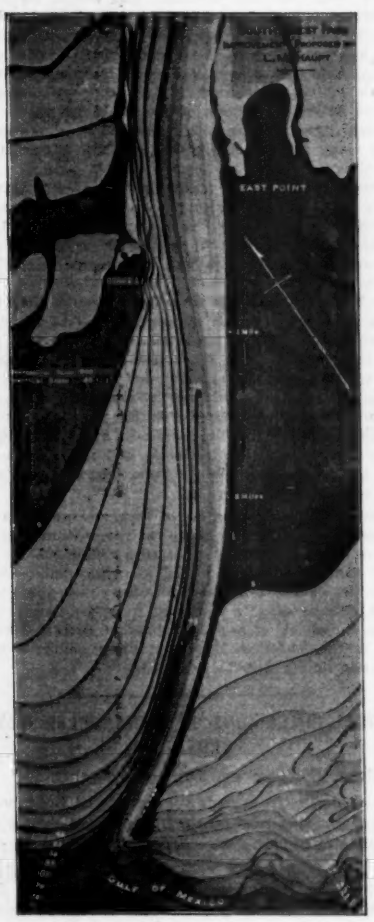


Fig. 2.—Plan Proposed by Prof. L. M. Haupt.

RELIEF MODELS OF SOUTHWEST PASS AND ALTERNATIVE PLANS FOR ITS IMPROVEMENT.

no application is made to the observed fact that the deepest water is always found at the concavities of the bends, due to the concentration of currents by centrifugal force and the deposits on opposite banks due to undercurrents caused by head and reaction, which should be used to remove material from the channel and to build up the natural counterpart to the reaction jetty.

(3) If the two jetties were to be built simultaneously 3,000 ft. apart on the crest of the bar where the average depth is 10 ft., the area would be but 30,000 sq. ft., or less than one-half that required, so that the full cross section of 70,000 sq. ft. must be developed by dredging before it would be safe to construct the second jetty, but this requires the removal of 15,541,200 cu. yds. of material (in situ) from the bar, requiring several years of time, and takes no account of the 100,000,000 cu. yds. which are annually supplied by the pass and which cannot be ignored, since this material will accumulate on the expanded bed of the stream and constantly feed the cut.

To place the "main reliance upon dredging," therefore, even at the very low price of 4 cts. per cu. yd., would seem to the writer to be an interminable and very unsatisfactory solution and it was to avoid leaving the problem in this condition that a plan was submitted to members of the Board of Engineers to utilize the energy of the stream by the construction of a single, concave reaction-jetty of sufficient dimensions and strength to control the currents and resist the waves, as shown in the figure herewith, and for which the jury at the Paris Exposition has seen fit to award the gold medal in recognition of its novelty and utility.

The thorough paper of the author is too comprehensive to be discussed in detail in a periodical where space is so valuable as in the Engineering News, yet the problem under consideration is one of national importance, and prompts at least these few suggestions as to an effective and expeditious remedy by a single jetty.

The sequel to the South Pass, as stated by Major Starling, is that "the whole of the west jetty was buried beneath the land, which had been formed by the accretion under its lee, except a few hundred feet at the sea end," and also, "It is said by those engaged in work at South Pass that Mr. Eads might have saved hundreds of thousands of dollars if he had had more accurate information about prevailing winds and currents." This knowledge being now of record should be utilized and the conventional parallel jetty system be improved upon. At all events it is apparent that the East jetty should be built first, and in a position where it will sustain and confine the current and not off on a mud flat half a mile from the channel. Should a second jetty ever be found necessary, it can readily be constructed to better advantage and at less cost than if included in the present plan.

The writer begs to take the liberty of rearranging the cross sections of the pass as shown in the paper of Mr. Starling and of adding the surface widths, maximum depths and elements of the alinement so as to enable the casual reader to interpret more readily the story of the river as revealed by its own mold.

By arranging the sections consecutively, and connecting them with the axis of the stream, as has been done in the accompanying cut, it will be seen at a glance that the pass swings gently with long radii from side to side, that in the straight reaches, notwithstanding even a contraction in the width, the depths diminish, whereas the best water is always on the concave side of the curves and it is deepest where the curvature is greatest, extending to the greatest depth of one hundred feet on the curve whose radius is three miles. The normal width for the ideal channel is about a quarter of a mile. If, therefore, two artificial banks were placed on the bar, having widths varying from 3,000 to 7,000 ft. apart, as has been proposed, with a normal area of, say, 70,000 sq. ft. as now existing in the pass, the resulting depth to be expected from the action of the river would vary from 23 to 10 ft., and any additional results as to channel section would have to be secured and maintained by dredging at great expense. On the other hand, the river has ample energy to create an ideal channel, as is demonstrated by the completed portion of the pass, and it merely remains to reproduce the same conditions on the bar by restricting the effluent by a substantial training wall of proper radius to scour out an ample channel for the largest ocean vessels.

Respectfully submitted,

Lewis M. Haupt, M. Am. Soc. C. E., etc.
107 No. 35th St., Philadelphia, Oct. 1, 1900.

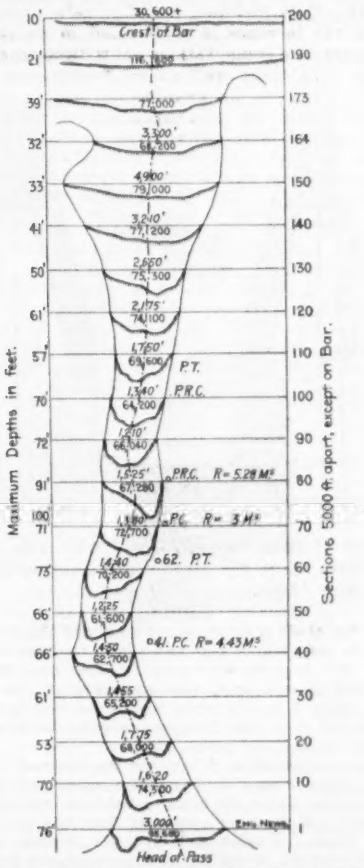
A $4,700,000 WATER BOND ISSUE has been awarded by the city of Denver, Colo., to Higginson, Prior & Co., of Boston. The bonds were authorized by popular vote, last spring, to buy out the Denver Union Water Co., or to build new works. It is said that the company asks $7,000,000 for its property.

THE PROTECTION OF BLAST-FURNACE LININGS.*

By S. S. Hartranft.†

Furnace-men of the present day agree very nearly as to the best cooling-devices for the protection of blast-furnace hearths and boshes, and the best location of the cooling-system in the brick-work for the maintenance of favorable furnace-lines throughout the blast. The replaceable bronze and copper plates are practically faultless; and there seems to be no reason why a furnace-hearth and bosh should not be held in good condition, by intelligent management and the use of replaceable plates, for a period several times the length of the average blast of to-day.

While furnace-men have taken these precautions to protect the hearth and bosh beyond the life of the lining, the portion of the lining above the mantle has been partly protected by some and wholly neglected by others. Some would not construct a furnace without mantle-plates, and others would not construct a furnace with them. In most cases, furnace-men have either trusted to Providence or



Sections of Southwest Pass at 5,000-ft. Stations.

to the bosh-plates for the continuance of favorable working-conditions above the mantle, and the prolongation of the life of the lining; consequently furnaces are constantly blown out for repairs to the lining, or for relining, when the hearth and bosh are in good enough condition to last through another blast.

The following extract from one of Mr. James Gayley's contributions on American blast-furnace practice is of interest in this connection:

One point particularly worthy of mention has been observed recently, viz.: That the removable bosh-plates of bronze and copper protect not only the bosh-wall, but also the whole of the upper lining, from the point where the stock strikes against the top-lining down to the mantle. The wear of the lining for double the production is only about half what it was when the bosh was protected differently. The result, as amply demonstrated by practice, is that the fuel-consumption does not increase with the length of the blast, as has been the usual experience; and it also follows that the production maintains its regularity.

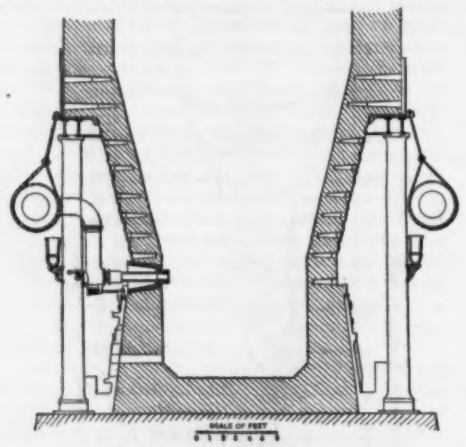
In other words, according to Mr. Gayley's statement, the melting and wearing away of the lining to large diameter above the mantle is retarded so as to increase the economical working-life of the furnace 100%. The working-life of a furnace depends upon the ability of the lining,

*A paper read at the Canadian Meeting of the American Institute of Mining Engineers.
†Buffalo, N. Y.

from the stock-line to the mantle, to withstand melting or wearing away, which causes extravagant fuel-consumption and irregular working. Consequently, it seems that furnace-men should endeavor to ascertain the lines necessary to insure good economical working-conditions, and to protect these lines as the hearth and bosh are protected, thereby making the life of the lining from the mantle to the top equal to the life of the hearth and bosh.

Mr. F. E. Bachman, my predecessor in charge of the Buffalo furnace, informs me that the furnace, as put in blast in 1895, had the following dimensions: Diameter of hearth, 11 ft.; diameter of bosh, 18 ft.; angle of bosh, 75°; and that it was provided with replaceabe copper plates up to the mantle, and three rows of double-pipe cast-iron plates of the ordinary type above the mantle. The inner 1¼-in. pipe was 2½ ins. from the inner edge of the plate and the outer 1¼-in. pipe was 6 ins. from the inner pipe, and parallel to it, both running lengthwise through the plate, which was 8 ft. in length. The first row of these plates was placed 5 ins. above the mantle, with the front edge of each plate 4½ ins. from the inside line of the brick-work; the second row was 2½ ft. above the first, with the front edge of each plate 9 ins. from the inside line of the brick-work; and the third row was 2½ ft. above the second, with the front edge of each plate 4½ ins. from the inside line of the brick-work.

After blowing-in, the furnace worked very well for the greater part of the first year, when it began hanging and slipping, which gradually became so pronounced as to interfere materially with the grade of the iron. About the end of the first year, the water-circulation was lost on the inner pipes of the three rows of plates above described; after which there was no more hanging and slipping,



Section of Blast Furnace, with Replaceable Copper Plates up to the Mantle, and Double-Pipe Iron Plates Above.

while the grade of the iron improved and the output increased. In about a year and a half from the time the inner rows of pipes were lost, the other rows were lost also; and, there being no water-protection left, the furnace soon enlarged at this point to such an unfavorable diameter and shape that it became necessary to blow out at the end of the third year.

On several occasions, I have cut the water off from the inside pipes in three or four of the upper rows of bosh-plates, usually after the furnaces had been in blast a year or more, and the inner pipes had been lost in a few of these plates. A quick and favorable response was invariably noticed, in the way of improvement in grade and increase in output.

The ledge or offset that forms above the upper row of plates by the wearing away of the brick-work from the original lines interferes with the regular descent of the stock in proportion as it grows larger; the effects of which (when the plates are placed, as is customary, with the front edge of each a few inches from the inside line of the brick-work) are generally noticeable about the middle of the blast. I think that the wearing away of the lining could be sufficiently retarded to insure the retention of favorable lines, through the period of an average blast, by six rows of plates above the mantle, placed 2½ ft. apart, with their front edges at least 9 ins. from the inside line of the brick-work.

It has been the experience of some furnace-men, who place plates above the mantle and extend them through the lining until the front edge of each plate is within a few inches of the inside of the brick-work, that the furnace does better work when the first row of pipes in the plates burns off, and the diameter of the furnace enlarges until the second or rear row of pipes prevents further enlargement in diameter. When the last row of pipes in these plates burn off, and all protection is lost, a further enlargement in diameter causes extravagant fuel-consumption and irregular working, to such an extent that it becomes necessary to blow out the furnace and put in a new lining. It seems, therefore, from experience with these plates, that in a furnace of modern lines, to secure the protection of plates and the retention of favorable lines for a period more nearly approaching the life of the hearth and bosh, the plates should be placed with the front edge from 9 to 12 ins. from the inside of the brick-work. This will permit an enlargement of diameter of from 18 to 24 ins., without destruction of the plates; and if the furnace can be held by the plates after this increase in diameter, a blast of regular work somewhat longer than ordinary might be expected. Plates set back from 9 to 12 ins. from the inside of the brick-work would not suffer so much from heat and abrasion, and would, no doubt, hold out for a much longer period than when placed according to the present custom. The construction might be such as to permit replaceable plates similar to the present replaceable bosh-plates; and when the most favorable lines to which the furnace should be held above the mantle had been determined, these plates could be paced with their front edges as close to the inside line of the brick-work as many furnace-men place their bosh-plates at the present time.

The accompanying cut, taken from a recent drawing made by an eminent blast-furnace engineer, shows the hearth and bosh of an 18 by 80-ft. furnace, with an 11-ft. hearth and 75° angle of bosh, fitted with replaceable copper plates up to the mantle, and double-pipe iron plates above the mantle.

I have had an opportunity recently to observe the result of fitting up a furnace with rows of solid cast-iron plates at the stock-line; and I am much pleased to find how well these plates, with an inner edge 5 ins. wide, placed in rows one foot apart, have worn, and have protected the lining at this point. I would not be surprised to see, before long, furnace-stacks plated from the mantle to a point above the stock-line with water-plates and solid plates. The only question difficult to decide will probaby be the point in the ascent at which the water-plates should stop and the solid plates begin.

Considering the great progress of furnace-practice in recent years, especially in the matter of the protection given to furnace-hearths and boshes, it seems that the linings from the mantle up have not had a corresponding share of protection, and that in the near future this portion of the stack will be equally protected with the hearth and bosh from the effects of heat and abrasion, so that a great increase in the length of blasts, or the amount of iron made on one lining, may be expected.

ECONOMICAL DIMENSIONS OF RECTANGULAR FILTER BEDS.

By John H. Gregory, Jun. Am. Soc. C. E.*

Many cities in the last few years have been confronted with the problem of the purification of their water supply by means of slow sand filtration, and engineers and water-works superintendents have been called upon to make designs for filtration plants. It is with a view to aiding those who are called upon to make such designs, that the writer submits the following formulas and diagrams relating to the economical dimensions of rectangular filter beds, which from experience he knows will be of value in making the necessary studies of arrangements of filters. It is not intended to treat of the most economical size for a filter bed, but, having assumed its size and that it will be rectangular in shape, to determine its most economical dimensions.

As a general proposition, other things being equal, it may be stated that, with a given number of filters, arranged in a certain way, the most economical dimensions will be those which give the cost of the outside and dividing walls a minimum. Two cases of arrangement only are treated, but they are the simplest and cover those most likely to occur in ordinary practice.

In the case of uncovered, rectangular filter beds of given area, it is assumed that the cost of the floor and filtering materials is not affected by changes in shape; similarly with covered beds, that the cost of covering also is not affected; and further that the beds all have the same dimensions. Let,

n = number of beds,
A = total area of all the beds in sq. ft.,
w = width of one bed in ft.,
l = length of one bed in ft.,
r = ratio of width to length of one bed,
C_o = cost of outside walls per lin. ft.,
C_d = cost of dividing walls per lin. ft.,
C = total cost of all the walls.

Then,

$$A = n\,w\,l.$$

Case 1: Filters arranged in Series (see sketch plan, Fig. 1),

Length of outside walls = 2 n w + 2 l,

Length of dividing walls = (n − 1) l,

Then the total cost of all the walls is,

$$C = C_o\,[2\,n\,w + 2\,l] + C_d\,(n-1)\,l; \qquad (1)$$

or, since $w = \frac{A}{n\,l}$, equation (1) becomes

$$C = \frac{2\,C_o\,A}{l} + l\,[2\,C_o + C_d\,(n-1)] \qquad (2)$$

The most economical dimensions, then, are when the total cost of all the walls C is a minimum; hence, placing the first differential coefficient of C with respect to l equal to zero we have,

$$\frac{d\,C}{d\,l} = 0 = -\frac{2\,C_o\,A}{l^2} + [2\,C_o + C_d\,(n-1)]. \qquad (3)$$

and solving this equation for l,

$$l = \sqrt{\frac{2\,A}{2 + \frac{C_d}{C_o}(n-1)}}. \qquad (4)$$

For the ratio of the sides we obtain by a simple operation,

$$w = \frac{2 + \frac{C_d}{C_o}(n-1)}{2\,n}\,l = r\,l, \qquad (5)$$

where,

$$r = \frac{2 + \frac{C_d}{C_o}(n-1)}{2\,n}. \qquad (6)$$

If the cost of the outside and dividing walls is the same per lineal foot, $C_d = C_o$, and equations (4) and (5) become, respectively,

$$l = \sqrt{\frac{2\,A}{n+1}} \text{ and } w = \frac{n+1}{2\,n}\,l.$$

Diagram (1) has been plotted from equation (5) giving the values of r for various values of n and $\frac{C_d}{C_o}$.

Case 2: Filters arranged in Double Series, Back to Back.—In Fig. 2, n must be an even number ≥ 4. The condition n = 2 is solved under Case 1. Following the same method as in Case 1,

$$C = C_o\,(n\,w + 4\,l) + C_d\left[\frac{n\,w}{2} + (n-2)\,l\right] \qquad (7)$$

or,

$$C = \frac{A}{l}\left[C_o + \frac{C_d}{2}\right] + l\,[4\,C_o + C_d\,(n-2)]. \qquad (8)$$

Placing $\frac{d\,C}{d\,l} = 0$, and solving for l,

$$l = \sqrt{\frac{A\left(2 + \frac{C_d}{C_o}\right)}{8 + \frac{C_d}{C_o}(2\,n-4)}},$$

and

$$w = \frac{8 + \frac{C_d}{C_o}(2\,n-4)}{n\left(2 + \frac{C_d}{C_o}\right)}\,l = r\,l, \qquad (10)$$

where r is the coefficient of l.

$$\text{If } C_d = C_o,\ l = \sqrt{\frac{3\,A}{2\,(n+2)}} \text{ and } w = \frac{2\,(n+2)}{3\,n}\,l.$$

Diagram (2) has been plotted from equation (10).

In practice the topography and location of the proposed site are often very important factors, and the preceding formulæ may not then strictly apply, in which case the engineer must use his judgment as to how far the previous results are applicable. It will be found, however, that even in such cases, the diagrams will be of great use in determining the dimensions approximately, when the number and arrangement of the filters is changed.

In conclusion, it should be noted that the above formulæ and diagrams are applicable not only to filter beds, but to many other problems, as, for example, the division of a settling basin into compartments, and in fact to any problem of a similar nature.

*Assistant Engineer, Improvement of Water Supply, City Hall, Philadelphia, Pa.

THE UNSUCCESSFUL SEWAGE PURIFICATION PLANT AT MADISON, WIS.

An instructive report on the operation of the sewage purification plant at Madison, Wis., was submitted to the City Council on Aug. 8, 1900, by Prof. F. E. Turneaure, Assoc. Am. Soc. C. E., who was appointed as city engineer some months after the plant was built. These works were a combination of chemical precipitation and rapid filtration, built under a most peculiar contract. A description of the works and the provisions of the contract was given at length in our issue of Dec.

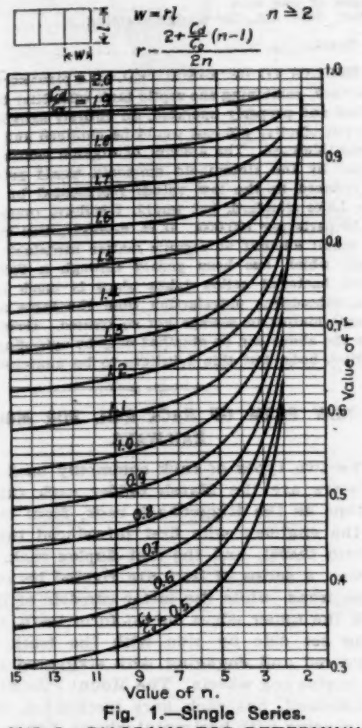


Fig. 1.—Single Series.

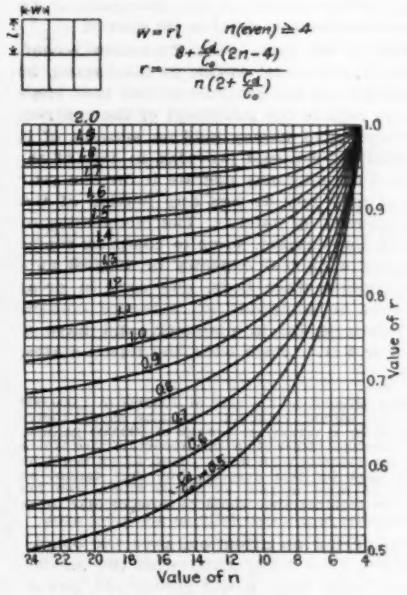


Fig. 2.—Double Series.

FIGS. 1 AND 2.—DIAGRAMS FOR DETERMINING ECONOMICAL DIMENSIONS OF FILTER BEDS.

28, 1899, while on Jan. 18, 1900, we recorded, with editorial comment, the abandonment of the works by the contractor before their acceptance by the city. Since this abandonment the city has operated the works. Prof. Turneaure's report is an admirable presentation of data for the use of the city in concluding how it can make good, at the least possible cost, the blunders which it committed through its failure to secure, or at least to follow, good engineering and legal advice in entering upon an expensive city improvement.

The plant was modelled more or less closely upon the English proprietary process of the International Purification Syndicate, the main features of which are the use of ferozone in circular chemical precipitation tanks of the Candy type and also the use of polarite as a filtering material.

The works, as built, included four precipitation tanks, having a combined capacity of about 200,000 gallons, and three filter beds with a combined area of 3,500 sq. ft., or about ⅛ acre, making the rate of flow through the beds some 9,500,000 gallons per acre per day, when operated continuously at the contract capacity of 1,200,000 gallons a day for the whole plant. The filter beds were designed to work continuously for two or three days, then rest one day. The gasoline engines, centrifugal pumps, sludge press, chemical mixers and other machinery were provided by the city.

The contract contained, among other unusual conditions, the following: The effluent should be as good as though a previous plan for chemical precipitation, followed by intermittent filtration, had been carried out and should equal in purity the waters of Lake Mendota, as shown by analyses made some years before; the cost of operation should not exceed $3,600 per year for 600,000 gallons of sewage per day.

The first part of Prof. Turneaure's report deals with the quantity and character of the sewage. Daily and hourly gagings of the flow are presented, from which, after allowing for various local causes for inaccuracy, he concludes that the ordinary dry-weather flow, and the flow during most of the winter, is about 400,000 gallons a day and the average for the year about 600,000 gallons. The maximum pumpage was about 1,000,000 gallons, and on several successive days, between July 17 and Aug. 6, the period covered by the gagings, the flow averaged 800,000 gallons. On May 11, 1900, there were 1,621 houses, 156 roofs, and 340 cistern overflows connected with the sewers. At six persons to a connection, the tributary population would be about 9,700. On the basis of the water consumption, 30 gallons per capita per day, the house and manufacturing sewage flow would be nearly 300,000 gallons a day, or only half the average total flow. The difference is accounted for as ground and roof water.

The quality of the sewage is thought to be about the same as the average for towns of the size of Madison, the great dilution by ground water being offset by the relatively small per capita water consumption. An average of analyses of Madison sewage, in the report of State Chemist Mitchell for Nov. 27, 1899, is taken to be fairly representative, and is compared with averages from three Massachusetts towns, as follows, the figures being parts per 100,000:

	Ammonia albuminoid.	Ammonia Free.	Oxygen consumed.
Madison	0.88	2.5	8.4
Brockton	1.00	3.1	4.9
Gardner	0.69	2.4	4.5
Marlboro	0.46	2.0	2.6

At times of a daily flow of 800,000 gallons the sewage is from 6 to 8 hours in reaching the disposal works, which affords time for "more or less bacterial action." At other times the time involved is only 2 to 3 hours, when the "sewage would be classed as fresh."

Analyses of the Madison effluent were made in October and November, 1899, and on July 18 and 21 and Aug. 2, 1900. The first set of analyses comprised eight samples, the second two, and the others one. In the accompanying table the averages for the first two sets of analyses are given first, then the later analyses, then the Lake Mendota standard, and finally the average effluent obtained by intermittent filtration at four Massachusetts towns in 1898.

Prof. Turneaure's comments on the chemical and other results shown by the works, with slight abbreviations, are as follows:

The quantities of chemicals used at the time these analyses (July and August, 1900.—Ed.) were made were sufficient to give representative results. The amount of lime used on Aug. 1 was indeed rather expensive. Somewhat better results could doubtless be obtained with increased amounts of chemical, but the improvement would not be great in any case and the cost would be largely increased. It will be noted from the tables that the results as indicated by the albuminoid ammonia are on the whole materially poorer than those shown in the earlier analyses. They are in my opinion about as good as can be expected with the present arrangement.

There are two probable reasons for the diminished purity of the effluent. One is in the clogging up the filter beds, rendering them less efficient and also making it impossible to filter all the sewage when the flow is large. The other I believe to be due to the use of a very large amount of lime at the time of the former analyses. The engineer of the disposal works informs me that there was used at times as high as 90 lbs. of lime each half hour, which would be equivalent to about 60 grains of lime per gallon for a flow of 500,000 gallons per day. The analyses of the state chemist also showed caustic lime in the effluent, a condition not permissible. The use of unusually large quantities of lime is also shown by the clogging up of the pumping machinery and pipes to such an extent as to almost entirely stop their operation.

At the time when sample (dated Aug. 1, 1900) was taken the three filter-beds had been specially cleaned to a much greater depth than usual, as explained later, and were in the best possible condition. They were thus able to filter all the sewage on that day, but the effluent was still but little better than the effluent from the tanks.

Compared with other chemical plants the results of the chemical process are about as good as could be expected and cannot be much improved upon. The filters accomplish relatively little. There is no oxidation of the organic matter (shown by the absence of nitrates), and whatever is removed is stored in the filter, a part of which material is taken out in the regular washing and a part remains in the filter, gradually clogging it up. It must be expected that under such conditions the results from the filters will steadily become worse. In fact the filters are on the whole of so little value that it is hardly worth while operating them.

The present plant was specially guaranteed to give as good results as the proposed filter system of Engineers Dodge and Nader. No experiments have been made to determine this point, but I believe that a system such as these engineers proposed (chemical precipitation and sand filters operating at 200,000 gallons per day) would, under efficient management, produce an effluent closely approximating the figures for the Massachusetts towns, and therefore much better than that from the present works.

CAPACITY OF THE PLANT.—The experience of the past few weeks indicates that the capacity of the precipitating tanks may be assumed to be the designed amount, 1,200,000 gallons for 24 hours. With ordinary or average sewage the results would at that rate be satisfactory. Two tanks have been operated for two days at a rate of 500,000 gallons, and the results were about as good as are ordinarily obtained with the four in operation.

The filters have not been able to take care of all the sewage for several months. During the period over which a close record has been kept sewage has been allowed to run off without filtering, on the average about 15 hours a day. The average quantity of sewage has at the same time been about 700,000 gallons. Each filter is washed once in three days, a process which requires 6 to 8 hours, or nearly the entire time of one man. (Ten hours a day are now put on this work.) In this operation the sand is quite thoroughly washed to a depth of about 4 ins. The filters have, however, become clogged to a greater depth, and some attempt has been made to thoroughly clean them. Their capacity has not been much increased, as they are now unable to pass more than about 500,000 gallons per day. The arrangement originally proposed for cleaning the beds, by flushing water from below, did not prove practicable, and in the nature of things could not. They are now ordinarily cleaned by washing with water from a hose, which is about as good an arrangement as practicable at the present time. For deeper cleaning the sand is dug up, and similarly washed.

Analyses showing the results obtained by Sewage Purification Plants at Madison, Wis., and elsewhere:

		Albuminoid ammonia.	Oxygen consumed.
Madison, October, 1899:	Final effluent	0.11	3.67
" November, 1899:	Final effluent	0.23	3.10
" July 17, 1900[1]:	Crude sewage	1.75	15.44
" " "	Chemical effluent	0.70	7.22
" " "	Final "	0.40	2.45
" July 20, 1900[2]:	Chemical "	0.48	8.81
" " "	Final "	0.37	5.92
" Aug. 1, 1900[3]:	Crude sewage	1.95	12.68
" " "	Chemical effluent	0.22	4.01
" " "	Final "	0.17	5.92
" " "	Settling barrel[4]	.0.42	9.94
" Lake Mendota standard		0.28	0.27
Brockton. Year 1898:	Filter bed effluent	0.01	0.13
So. Framingham. "	" "	0.02	0.18
Gardner. "	" "	0.06	0.53
Marlboro. "	" "	0.03	0.34

[1]Daily flow of sewage, 730,000 gallons; precipitant, 5 grains of alum and 4 grains of lime per gallon.
[2]Daily flow of sewage, 1,042,000 gallons; precipitant, same as July 20.
[3]Daily flow of sewage, 472,000 gallons; precipitant, 30 grains lime.
[4]This was designed to imitate a septic tank.

SLUDGE PRESSING.—For a considerable time, as is well known, a part of the sludge was run upon the marsh without pressing, the amount of sludge exceeding the capacity of the plant. This was doubtless due to the excessive quantities of lime used. With a hard water the addition of each pound of lime produces about 3½ lbs. of sludge, independent of the amount of organic matter precipitated. A reduction of the amount of lime used has decreased the sludge so that all can be pressed, but the quantity that is now pressed when lime is used is 5 to 6 tons per day, a very high amount and nearly equal to the capacity of the press. With alum the quantity may be reduced to about 3 to 4 tons. In my opinion the sludge should not be deposited on the marsh, but should be hauled away and spread upon land. The sludge from a lime treatment would not be suited to this, but with alum used as the precipitant the sludge ought to be of some value as a fertilizer, and it could probably be disposed of at a moderate expense.

PUMPING AND OTHER MACHINERY.—The rated capacity of the pumps is about 1,800,000 gallons per day for the full lift of 23 ft. Their actual capacity at the present time is considerably below this, due probably to wear of the impellers. This is a source of a considerable loss of power. The lack of capacity in the pumping machinery does not, however, interfere with the operation of the plant, as it is at present sufficient to take care of the sewage faster than it can be handled by the disposal works. Some improvements can be made which I believe will reduce the expense of pumping, but these and some other matters, such as a house for chemicals, an improved arrangement for the mixing of chemicals, etc., will depend upon the future methods of operation and will therefore be left for subsequent consideration.

COST OF OPERATION.—The high cost of operation of the present plant is probably its greatest fault, and it is here that the greatest relative improvement can be made.

The total yearly cost of operation at the rate of the past 6 or 8 months is very nearly as follows:

Wages of 6 men at $325 per month	$3,900
Chemicals, 1½ tons lime per day at $6.25 per ton	3,400
Gasoline, $210 per month	2,520
Repairs and incidentals	600
Total	$10,420

This does not include depreciation of plant, repairs to building, and replacement of parts which would occur at infrequent intervals, but would be relatively large items, such as putting in new pump impellers, important parts of engines, or other machinery, etc. Of the men employed, two attend the engines and take general care of the machinery. One is occupied most of the time washing filters, and two are employed during the day and one at night pressing the sludge, attending to the chemicals, etc. The night engineer assists in the sludge pressing.

The above items of expense should be divided between the cost of pumping the sewage and the cost of disposal proper.

For simply pumping the sewage, a day man and a night man would be necessary, although, as it is, each of these gives considerable of his time to the rest of the plant. The power used is partly for pumping and partly for operating other machinery connected with the disposal works. The engines are nearly always in operation, and these will furnish about 20 actual horse power, which may be taken as about the power required. Tests made by Messrs. Baus and Minch of the university showed that the various machines required the following power:

	HP.
Rotary pump for cleaning filters	2.32
Sludge pump	3.52
Dynamo	1.48
Mixer, lime pump, shafting and one engine	5.50
Large centrifugal pump (underloaded)	8.07

Taking the power required for mixer and lime pump at say 2 HP., and noting that the rotary pump is used for but one-third of one-tenth the time, the power required for operating machines connected with disposal will be as follows:

	HP.
Sludge pumps	3.52
Mixer and lime pump	2.00
Rotary pump about	1.00
Total	6.52

Besides this, about 20% of the work of the large pump is done in repumping sewage used for mixing chemicals and washing the filter beds. On the average, therefore, nearly one-half the power is required for the disposal works and about one-half for pumping. We have then the total cost of pumping about as follows:

Wages of two men at $120 per month	$1,440
Gasoline, say $110 per month	1,320
Repairs, etc. (one-half)	300
Total	$3,060

The cost of disposal proper will then be:

Wages of four men at $205 per month	$2,460
Gasoline at $100 per month	1,200
Chemicals	3,400
Repairs (filter cloths $120)	300
Total	$7,360

These figures are based on the experience of the past 6 to 8 months. At the present time less chemical is being used than estimated above and gasoline is now costing slightly less, which would reduce the cost of disposal alone (not including the pumping) to about $6,000 per year. This is about as low as it can be brought with the present system, and if provision is made for the carting away of the sludge, the cost will be considerably increased. The average quantity dealt with is close to 600,000 gallons per day, on which basis the guaranteed cost was to be $3,600.

The cost of disposal is thus seen to be about double the figures estimated by Engineers Dodge and Nader ($3,000) and given in the contract as maximum figures. The cost during operation by the Sanitary company was certainly higher than this, owing to the large amount of chemical used.

SUMMARY.—Summarizing the results of operation of the present plant, it may be stated that the purification effected is inadequate, consisting for some time past of but little more than the removal of the suspended matter, and leaving an effluent containing as much organic matter as the raw sewage of many places; that the effluent is not approximately up to the guaranteed standard, that the capacity of the filters to even strain the sewage is not one-half the guaranteed amount, and that the expense of disposal is nearly double that stated in the contract.

As a result of his study, Prof. Turneaure recommends that the disposal works, as they stand, be not accepted from the contractor, and that steps be taken to require the fulfilment of the contract or the refunding of money paid on account of it by the city. The contract provides, in case of rejection, that the city may operate it for one year and that it may buy at cost any portion of the plant not covered by patents. The remodelling of the plant is also advised, so as to comprise septic tanks having a cubical capacity of 400,000 gallons and contact filter beds, one acre in area, which should be composed of "screened cinders not finer than ½ in. in diameter, and have a depth of 3 or 4 ft." Such beds, the report states, should be

able to purify effluent at the rate of 700,000 to 1,000,000 gallons per day without clogging. One acre should therefore be ample for a volume of sewage of 600,000 gallons, as it is the average rather than the maximum rate which determines the capacity of a filter. Sand filters could be successfully used for this purpose, but they cannot be operated in the same manner as coarse filters, and for this reason the required area would be three or four times as much, and they would cost fully as much per acre.

Besides requiring no attention, save the operation of valves, thus doing away with the service of one man, such beds would reduce the power required at the plant by 8% of the present total.

The period of retention in the septic tanks necessary for the Madison sewage is taken as 8 to 10 hours, so that, allowing for the space occupied by sludge and scum, a cubical capacity of 400,000 gallons is held to be sufficient for an average daily flow of 600,000 gallons. The present sludge press could be used whenever it became necessary to remove sludge from the septic tanks, employing two men temporarily for this purpose. As to using portions of the present plant for septic tanks, the cost of the proposed changes and the results that might be expected thereafter, Prof. Turneaure says:

The question of using the present plant or a part of it as a septic tank has been considered. The chemical tanks are not of the form best suited for this use, and I do not believe they would be satisfactory, although they might give good results if not operated too rapidly. This could be determined by trial, but some changes in the piping would, however, have to be made. The filter-beds could be readily changed into suitable septic tanks, which would have a combined capacity of about 200,000 gallons. The cost of the necessary changes, and a wooden cover, would be about $800. The cost of an additional tank of 200,000-gallon capacity would be about $2,700, but if the present plant becomes the property of the city it would be wise to defer the construction of the additional tank until the suitability of the chemical tanks can be determined. If none of the present plant is retained, the cost of a tank of 400,000-gallon capacity (divided into two parts) would be about $5,200.

SUMMARY OF COST.—For a complete new plant the estimated cost would be as follows:

Filter beds	$6,000
400,000-gallon tank with piping, etc	5,200
Total	$11,200

If the present filter beds are used, the cost would be:

New filter beds	$6,000
Changes in old filter beds	800
200,000-gallon tank	2,700
Total	$9,500

If it should prove practicable to use the present chemical tanks also, then the cost would be:

For filter beds	$6,000
Changes in old filter beds	800
Changes in chemical tanks	600
Total	$7,400

In these estimates it has been, of course, impossible to take into account the cost of the present plant to the city as finally determined, or the price demanded for portions of the same. I have made recommendation of improvement along the lines which I think should be followed, whether the city does or does not retain the present plant.

COST OF OPERATION.—The plant as proposed requires practically no attention, beyond the operation of valves, and occasionally cleaning the tanks. I will, however, assume that one man will be required in addition to the two engineers for pumping. The cost of disposal (in addition to the cost of pumping) would then be as follows, which I believe are conservative figures:

Wages of one man	$[illegible]00
Labor, lime, etc., for sludge pressing	300
Total	$[illegible]00

RESULTS TO BE EXPECTED.—If a plant such as above described, combining the septic tank with filter beds be installed and properly operated, an entirely satisfactory and non-putrefactive effluent would be obtained and at a very reasonable cost. The amount of organic matter as represented by the albuminoid ammonia would probably not be reduced to the low values represented by the Mendota Lake standard, but would, I believe, range from .05 to .10 parts per 100,000. It is, however, well known that the small amount of organic matter contained in an effluent which has been passed through a filter bed in which bacterial action takes place is much less liable to a subsequent putrefaction than the same amount of organic matter in sewage not so treated. Greater purity than the above can be obtained only by extending the area of filter beds, but this I believe to be unnecessary.

A NEW FORM OF RACK RAIL FOR MOUNTAIN RAILWAYS.

The two types of rack commonly used on rack railways are the Marsh ladder rack (known in Europe as the Riggenbach rack, from the name of the engineer who first introduced the Marsh system there), and the Abt duplex rack. In the former, a series of bars are riveted between two angle irons, while the latter consists of flat bars with the upper edges cut to form teeth, the bars being set side by side with the teeth slightly staggered and engaging with staggered teeth on the engine cog wheels. The Mount Pilatus Ry., in Switzerland, has rack bars toothed on the sides and gearing with horizontal wheels, but we believe this is the only line on which this system has been

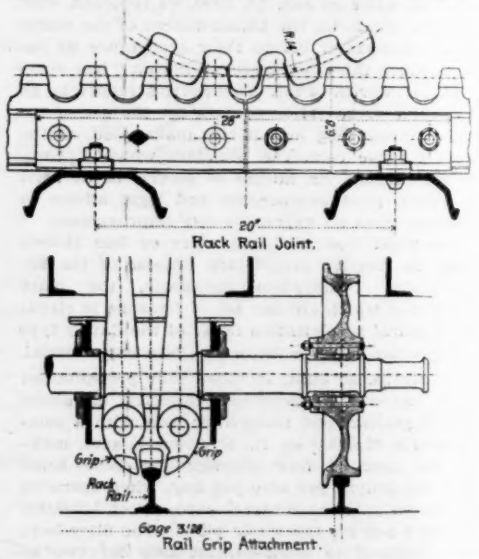


Fig. 1.—Rack Rail and Grips of the Jungfrau Rack Ry. (Switzerland.)
Emil Strub, Inventor.

adopted. For the Jungfrau Ry., ascending the Swiss mountain of that name, a new form of rack was devised by Mr. Emil Strub, of Clarens, Switzerland, who was technical director during the preparation of the designs for this line. Mr. Strub was formerly Inspecting Engineer to the Swiss government for all mountain lines, and afterwards Engineer-in-Charge of the Bernese Overland Rys.

In the Strub system, the rack rail is a large T-rail with an exceptionally deep head, which is cut to form the teeth. One of the special features

is that the sides of the rail head flare outward from the bottom to about half the height of the head, these flaring surfaces forming a seat for grips to prevent the vertical pressure of the pinion teeth from lifting the engine so as to become derailed. Such accidents have occurred and are specially dangerous on lines of this character. The grips also prevent lateral displacement of the cog wheels, and furthermore can be used as

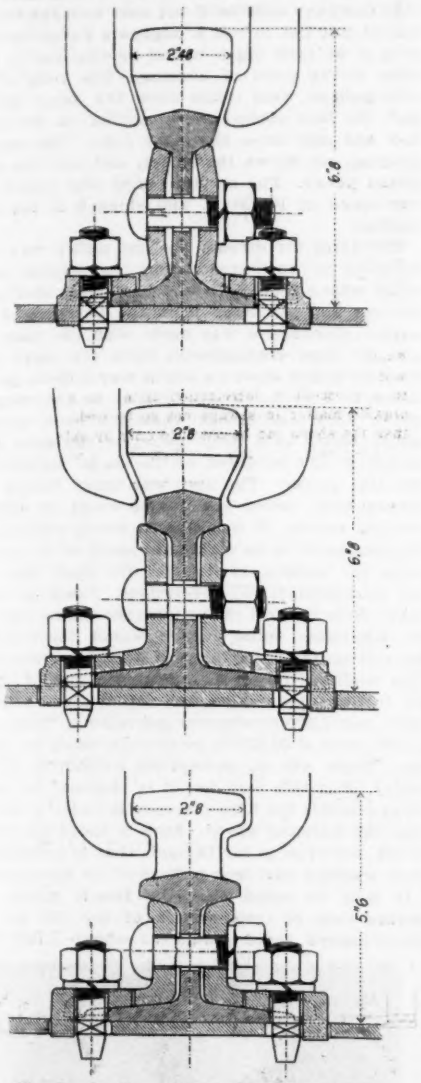


Fig. 2.—Sections of the Strub Rack Rail.

brakes by forcing them into contact with the rail head. Fig. 1 is a partial cross-section of the track and engine, showing the form of rack rail and grips. It also shows the form of the teeth. Fig. 2 shows rack rails with different forms of heads to receive the grips. Fig. 3 is a section of the track of the Jungfrau Ry., from which it will be seen that uniform attachments are used for the

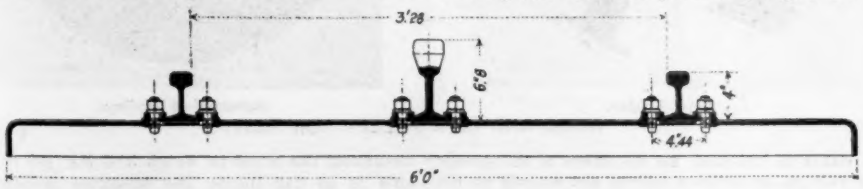


FIG. 3.—CROSS-SECTION OF TRACK OF THE JUNGFRAU RACK RY., LAID WITH THE STRUB RACK RAIL.

track rails and rack rail, thus simplifying the construction. The rack is of rail steel having a mean tensile strength of 29 tons per sq. in., with 20% elongation, and its weight is 68 lbs. per yd. In the cutting of the teeth, two 1-in. holes are first drilled at the bottom of the tooth-space, almost touching each other, and saws working at the requisite angle then form the flanks of the teeth. The metal thus loosened is readily removed, and the wedge-shaped bottom of the space is milled out. The rack is then cut to length, the bolt holes are drilled, and the burr or fin is chipped or filed off by hand. The bar is finally dipped in a bath of tar. The bars are manufactured by the Usines de L. de Roll, of Gerlapingen, Switzerland.

It is claimed that by providing safety grips, grades of over 25% can be operated successfully, especially if electric power is used, as in this case the pressure on the teeth is constant, and is divided equally between the two pinions, while the only vertical forces are those formed by the components of the tooth friction, the inclination of the tooth flank and the push of the train. The grips do not affect the frog and switch construction, which is similar to that employed with other rack-rail systems. The switches are fitted with movable rack tongues, which are operated by a lever and allow the grips to pass freely. They have proved entirely satisfactory under heavy traffic. The Strub type of rack is claimed to combine the safety of the Pilatus type with the durability of the Marsh type and the light weight of the Abt type, while avoiding certain disadvantages possessed by each of these other types.

PROPOSED SPECIFICATIONS FOR STEEL RAILWAY BRIDGES.*

By J. W. Schaub, M. Am. Soc. C. E.†

Theory and practice both tell us that a moving load on any structure produces a more destructive effect than a fixed load. The action of the moving load, as distinguished from the fixed load, is an inertia effect, and the work done in overcoming this inertia must be absorbed by the various members of that structure, excepting that which is absorbed by the springs on the vehicles.

In a railway bridge the total load may vary from the sum of the fixed and moving loads, when the train is moving at a slow speed, to some approximation of the sum of the fixed load and twice the moving load when the speed is such that the weight of the train may be taken as falling freely to the extent of the deflection of the structure as a whole. The experiments (Transactions American Society of Civil Engineers, Vol. XLI, page 410) made in 1897 by Mr. Turneaure, show that the effect of speed alone is of no practical importance, unless it be for very short spans (say 40 ft.), and this conclusion is warranted by the deductions from theory alone. In addition to this inertia effect, commonly called impact, there are vibrations produced, owing to the unbalanced mechanism of the locomotive, and imperfections in the track and wheels. The experiments made by Mr. Turneaure show that speeds greater than 20 miles per hour for short spans, and 35 miles per hour for long spans, invariably cause large vibrations. In general, the vibration increases with the speed, but not as rapidly as the square of the speed, as the theory of centrifugal force would suggest. Moreover, any imperfections in the design of the bridge itself may be shown by increased vibrations, both vertically and horizontally. This was brought to my attention very forcibly in the case of a bridge with floor beams having hangers eccentrically loaded, a defect which was remedied by introducing equalizing hangers, thereby doing away with the eccentric loading, and at the same time reducing the vibrations very perceptibly. In another case, a bridge having wooden stringers which were overloaded to the extent that they deflected abnormally, the effect of a moving load at high speeds, produced excessive cumulative vibrations. In this case, the addition of another stringer under each rail caused these excessive vibrations to disappear.

The experiments made by Mr. Turneaure show that these imperfections in the design of a bridge, and all designs are imperfect, produce secondary stresses which are far greater than those produced by impact and vibration. By means of an extensometer he measured the stress in the bottom outside flange of a girder 25 ft. long, to be 180% of the computed value, whereas the bottom inside flange showed a stress 45% of the computed value.

All of the effects of a moving load can then be provided for, as though it were a purely fixed load, if we allow a proper percentage for impact and vibration. This percentage can then be added to the sum of the fixed and moving loads and the whole treated as a fixed load. In any member of a bridge, the total effective area of the cross section is used in overcoming the total effect of the fixed and moving loads. If we provide a proper percentage for impact, and proportion the member so that the resulting stress shall never approach the elastic limit, no fatigue of the metal will result, and the celebrated experiments made by Wohler rather confirm this view, than justify any provision for fatigue. In other words, if the resulting stress will never approach the elastic limit, the metal is not susceptible to fatigue, and consequently the load can be applied an indefinite number of times.

Let L = moving load; D = fixed load; I = impact and vibration; then ignoring the Launhardt formula, which is based on Wohler's experiments, as inapplicable to bridge design, a common practice has been to provide for impact by making I = L; that is, allowing 100% for impact and vibration for all lengths of spans. This does not seem rational, and the experiments made by Mr. Turneaure and presented to the American Society of Civil Engineers, Dec. 7, 1898, do not justify such an assumption. These experiments show that the increase in deflection due to impact and vibration, caused by locomotives running at high speed, varies with the length of the span, being likely 40 or 50% for spans less than 50 ft. in length and decreasing rapidly for longer spans.

Having provided for impact and vibration, we can then provide for the sum of D, L and I as though the whole were a fixed load. Assuming a metal with an elastic limit of not less than 30,000 lbs. per sq.in., and allowing a margin of 100% for safety within the limits of elasticity, the proper unit stress to allow would be 15,000 lbs. per sq. in., both for tension and compression, the latter to be reduced by introducing the same in a proper column formula. By this method of proportioning, a constant unit stress is used for all members, the value of "I" providing for all the effects of the moving load in every part of the structure down to a single rivet.

The question might be asked, Would it not be just as well to make the value of "I" vary with the length of the span covered by the moving load? This, I understand, is now the practice of the Pennsylvania R. R., and also that of several prominent bridge engineers in this country. This gives rational results for the chord members, but for web members near the center of the span, special values must be used. Moreover, for bridges with heavy ballast floors the same impact would be added to the moving load as for bridges with ordinary timber floors, which is not rational. The percentage for impact, or the value

$$\frac{I}{L},$$

should be dependent upon the ratio of the moving load to the total load, as previously shown.

In the present state of information regarding impact, it must not be supposed that any one formula can be made to cover the widely varying conditions under which we find impact to exist. For example, taking one element of impact alone, such as the counterweights in the drivers of the locomotive. A particular engine on one span may produce excessive cumulative vibrations, whereas the same engine in another span of the same length, but with different panel lengths, may produce no cumulative vibrations at all. So that the question of impact is a complex problem, indeed, and the only thing to do, in the present state of our knowledge, is to adopt some rational method in proportioning our bridges, and the method proposed is certainly rational and entirely on the side of safety.

Based on the impact formula given by the following equation, which was first proposed by Mr. H. S. Prichard, in 1895, I have prepared a specification for steel railway bridges which I beg to submit, and in order to save time I will only touch upon such features in these specifications which are different from the usual requirements.

$$\frac{I}{L} = \frac{L}{L+D} - 0 \quad . \quad . \quad I = L \times \frac{L}{L+D}.$$

The minimum moving load which is to be used in proportioning is 1,000 lbs. per lin. ft. This, of course, is to be combined with a wind load at 30 lbs. per sq. ft., blowing horizontally, to obtain the maximum overturning moment in high bridges. This train load, of 1,000 lbs. per lin. ft., is just able to withstand this wind pressure without overturning the cars, so that as long as the cars remain on the track they can be considered as a part of the total area exposed to the wind. Impact is provided for movable bridges while in motion only. This must not be understood to mean that movable bridges can have a moving load on them while in motion. This impact is made a part of the fixed load, and is only another way of providing a lower unit stress for the fixed load while in motion. The impact for riveted connections of the floor system is made 125% of the moving load. This is made large in order to take care of all contingencies which may arise, such as eccentric connections, tension on rivet heads, etc. For all other members the value of "I" is made dependent upon the ratio of the moving load to the total load, as previously explained by the equation.

The maximum wind load is 30 lbs. per sq. ft., acting on all exposed surfaces, whereas the usual requirements are 50 lbs. per sq. ft., when no train is on the bridge.

*Abstract of a paper presented at the meeting of the Western Society of Engineers, Oct. 3.

†1650 Monadnock Block, Chicago, Ill.

The experiments made on Mount Washington in 1890, and the observations on the effects of the St. Louis tornado by Mr. Baier (Transactions American Society of Civil Engineers, Vol. XXXVII., page 285), show that a pressure of 30 lbs. is ample, and with a unit stress of only half the elastic limit this wind pressure could be doubled with safety. The Washington University in St. Louis has fitted up a means of measuring the actual wind pressure in terms of the velocity, and Prof. Nipher has informed me that as the wind blows he will be able to give us the information we are all looking for, and which has never been supplied.

Tension and compression are provided for at 15,000 lbs. per sq. in. As long as we confine ourselves to within the limits of elasticity, there is no reason why any difference should be made between tension and compression. To be sure, the latter value should be reduced by some column formula, and the formula here proposed is the Rankine-Bouscaren formula, with the 18,000 in the denominator changed to 15,000. This change is made in order to discourage the use of slender columns. No distinction is made between square ends and pin ends, and one formula is intended to cover all conditions. The tests so far made on bridge members have been made in a testing machine, and it is a question if we are justified in assuming that the same conditions obtain in a bridge as in a testing machine. In order to be on the safe side, it is better to make all light members with riveted connections and then treat them as though they were pin connected.

The shear on machine driven rivets is taken at 12,500 lbs. per sq. in. This forms the basis of the subsequent values given for tension and bearing, and was arrived at by assuming the elastic limit for rivet steel at 27,500 lbs. per sq. in., and using half this value, reduced by 10% for shear. Within the limits of elasticity there is no reason why the shear cannot be taken at the same value as for tension. The bearing on rollers is given by the formula 500 × (D) per lin. in., in which (D) is the diameter of the rollers. This is according to the formula proposed by Prof. C. Bach, P = K × D, in which "K" was taken, for steel rollers on a steel track, at 500 lbs. per lin. in. The value of "K" given by Prof. Bach, for the same conditions, is 851 lbs per lin. in.

It is recognized that fatigue in steel can occur when a reversal of stress approaches within the elastic limit, according to the experiments made by Prof. Bauschinger (Foppel's "Technische Mechanik"), so that alternate stresses of tension and compression are provided for separately, and the required sections are added in determining the total sectional area.

Rolled and built beams to resist bending are to be proportioned by the moment of inertia of their cross-sections. If we allow for any holes cut in the web, or reinforce the same properly, it is certainly good practice to consider the web in proportioning any beam. Moreover, it encourages the use of thick web plates without stiffeners, rather than thin web plates with stiffeners.

Deck plate girders are to have no cover plates on the top, but they are to be put on the sides of the top flange. This is to avoid the dapping of cross-ties and boring the ends for rivet heads, and makes one cross-tie just like the other. This is a great advantage to the bridge carpenter when any ties have to be renewed, or it becomes necessary to bunch the ties in order to get down through the floor. Moreover, the dapping weakens the cross-ties and should be abolished. With this form of top flange the lateral bracing can be kept free from the cross-ties by attaching the same to the lower angles, and thereby doing away with the trouble from loose rivets in the bracing, owing to the deflection of the cross-ties.

Intermediate stiffeners are provided according to the maximum shear at any point in the web, by the Gordon formula in which the numerator is made 18,000 lbs. In using this formula it is assumed that the web of any girder under consideration is divided up into lengths each equal to the depth of the girder, when each imaginary section is treated as a column in which "H" is the ratio of the depth of web to its thickness. The term shear on the web is used only to convey the idea that there is a vertical load on each imaginary section of the web, and the intensity of this load is assumed as uniformly distributed on the horizontal area of each section. Now, as long as each section is imagined to be as long as the web is deep, this horizontal load must be just equal to the vertical shear on the web at that point. In case it is found that each web section can carry the shear as a column, no intermediate stiffeners are required. In no other instance is the so-called shear on the web of a girder recognized, for if we accept the definition of a shear as the effect of a sliding between two contiguous surfaces, such a thing as shear on the web of a girder cannot exist, and all of the tests ever made on rolled and built beams show that they fail by the buckling or tearing of the webs on diagonal lines, or owing to insufficient rivet bearing at the ends, excepting, of course, such failures as are due to weak flanges.

The stiffener formula proposed, provides for intermediate stiffeners to carry the algebraic sum of the loads, or shear, at any point. Now, it can be shown that if we can in some way get the load into the web, that no stiffeners will be required whatever, excepting, of course, the end stiffeners. Experiment shows that after we get the load into the web, the web is actually stiffer than it was before, so that stiffeners need only be provided to get the load into the web and not to carry the maximum shear at any point. Would it then not be more rational to proportion our intermediate stiffeners to carry only the maximum concentrated load at any point, rather than the maximum shear?

If we adopt this method of proportioning, we will find that very small angles will suffice to carry the vertical loads into the web, and it was thought perhaps better to adhere to the former methods to avoid the use of small intermediate stiffeners. However, there is no question, that for through plate girders we need provide for intermediate stiffeners only to attach the floor system to the web, and that between the floor beams, or panel points, no intermediate stiffeners are required, no matter how long the panels are, or how thin the web may be; but for practical reasons, it is best to put in the intermediate stiffeners to take out any buckles or initial stresses which may exist in the web.

The neutral axis in any compression member must coincide with the center of the cross-section as near as practical. This is to prohibit the use of unsymmetrical sections, or sections which are not balanced about the center line of the cross-section. Placing the pin in the neutral axis of an unsymmetrical section does not distribute the load uniformly over the entire section, but produces bending in addition to the direct load.

All holes in the flanges of rolled beams are to be drilled. This is to prohibit the punching of holes in the flanges of rolled beams used as stringers, so as to avoid the torture to the metal necessary in punching through metal having a surface which is not at right angles to the punch, and results in distorted holes on the under side of the flange.

The borings for chemical tests are to be taken from the pulling or bending test pieces, and not from the ingot, bloom or slab. This is to establish a closer relationship between the physical and chemical tests. The usual practice, in taking the borings from the ingot, is open to criticism, in that the borings can be taken so as to avoid segregations of impurities where they are known to exist in the ingot.

The paint to be used is specified to be made of lamp black and boiled linseed oil. To this should be added a little litharge or the mon-oxide of lead to secure a hard surface to the paint. Theoretically red lead is the ideal paint, but it is expensive and requires too much skill to properly apply it. Red lead as used on work for the Canadian Pacific Ry. in 1884 was very satisfactory, and the secret of it was that the paint was mixed with japan to make it dry quickly and avoid the streaking or running of the wet paint. This, I believe, has been the principal objection to the use of red lead, aside from the extra cost.

The methods herein proposed are advocated because they meet present ideas of the effects of impact and provide for them in a rational and intelligent manner. Using the values for impact, obtained by the equation given above, which makes no allowance for the effects of the springs on the vehicles, is certainly rational and entirely on the side of safety. At some future time when we know more about the effects of impact, we can perhaps use a better formula, but, in the meantime, we should proportion our bridges for impact by some such methods as herein proposed.

Moreover, existing structures which are too light to carry present loads at high speed can be intelligently analyzed, and the exact margin for impact found. For example, in an iron bridge recently examined, I found the material in the main trusses strained up to 15,000 lbs. per sq. in. with no allowance for impact. The natural conclusion is that this bridge is perfectly safe at slow speeds, say, not to exceed 15 miles per hour. In another case the margin found for impact was about half that given by the formula, so that a greater speed is permissible

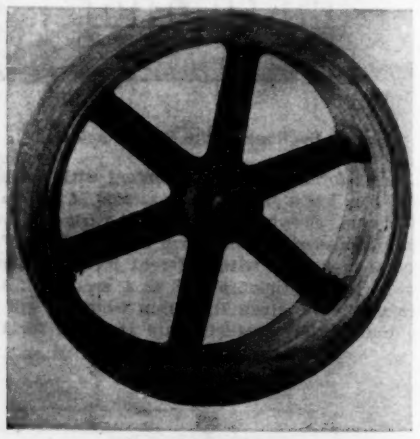
A SPEED TEST OF A WOOD AND IRON PULLEY.

A pulley with iron center or spider and wood rim, 46½ ins. diameter and 16 ins. face, was recently ordered by the Crocker-Wheeler Electric Co., of Newark, N. J., to be fitted to a 4-in. shaft and it was required that it should be tested to a rim speed of 9,000 ft. per minute, that being the service speed of the pulley. The order was placed with the Dodge Mfg. Co., of Mishawaka, Ind., and that company concluded not only to make the required test but to test a duplicate pulley by running it at very much higher speeds, and if possible to the point of bursting. The rims of the two pulleys were made from the same lumber and the iron spiders were molded on the same day and cast from the same ladle. The accompanying cut shows the spider, and also the completed pulley. The service pulley was tested to a rim speed of 10,000 ft. and shipped to the purchasers.

The plant for driving the test pulley was the installed in an unused room, connection being made with a line shaft, and barricades erected to prevent any accidents from the bursting of the pulley. Connection was made with the main engine by rope transmission from the main jack shaft to a line shaft on which was a 60-in. pulley bolted to a 14-in. all-wood pulley on the countershaft. This countershaft carried a 48-in. wooden pulley bolted to a 16-in. pulley of the same construction and mounted on the same mandrel as the test pulley. The test was made during the dinner hour, when the engine could be run at varying speeds. It was started slowly and gradually increased to its maximum speed of 75 revolutions per minute, giving the line shaft 200 and the countershaft 857 revolutions. Readings were taken from the test pulley until the engine reached its maximum speed, which would theoretically have given the pulley a speed of 2,571 revolutions. The readings, however, indicated a loss of about 5% in the transmission, the actual speed being a little over 2,400 revolutions per minute. This gave a rim speed of 29,228 ft. or over 5½ miles per minute. There was no perceptible weakening of the pulley after this test, but it is proposed to make arrangements for higher speeds in order to ascertain the bursting speed. Such a speed as above noted, however, is far beyond what is practicable with ordinary cast-iron pulleys of the same size.

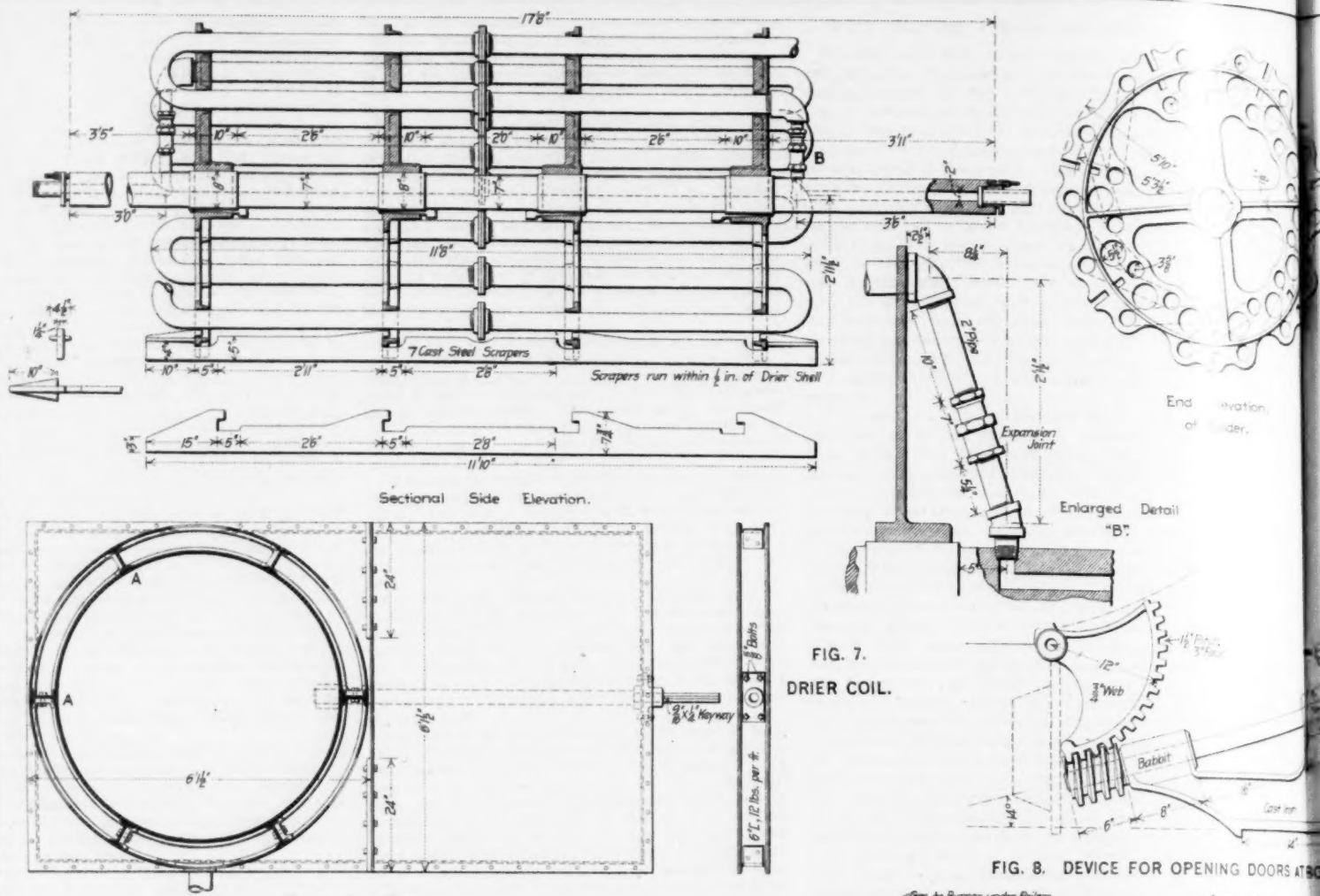
It may be noted that the tensile stress per square inch of cross-section of the rim at the above-named speed would be about 1,700 lbs., assuming the wood to weigh 37.5 lbs. per ft., and this is so far inside the breaking strength of sound wood that bursting could hardly have been expected at this speed. A cast-iron pulley of this diameter run at such a speed would have a rim tension of about 20,500 lbs. per sq. in. and would be apt to give way before reaching such a speed on account of the bending of the rim, due to the action of the pulley arms when the rim stretches under the tension due to high speed. The reason why wooden rim pulleys can run at so much higher speed than cast iron is their small weight and their elasticity which enables them to yield without injury to the bending stresses which occur at high speed.

Iron Spider.



Assembled Pulley.

WOOD AND IRON PULLEY FOR TEST.


17'8"
3'5"
10"
2'6"
10"
2'0"
10"
2'6"
10"
3'11"
B
3'0"
11'8"
2½"
7 Cast Steel Scrapers
Scrapers run within ½ in. of Drier Shell
10"
5"
2'11"
5"
2'8"
15"
11'10"
Sectional Side Elevation.
A
A
6'½"
24"
24"
6'½"
⅞" Bolts
⅞"×1" Keyway
6'1", 12 lbs. per ft.
Sectional Plan.
8½"
2" Pipe
10"
7"
5½"
Expansion Joint
Enlarged Detail "B".
5'10"
5'3½"
3⅝"
End Elevation of Cylinder.
FIG. 7.
DRIER COIL.
G
12"
¾" Web
Babbit
6"
8"
Cast Iron
4"
FIG. 8. DEVICE FOR OPENING DOORS AT BOTTOM OF DI
5'0⅜"
5'3"
6'2"
5'1"
5'11"
5" Steel Beams
5'7"
¾" Bolts
Hopper
5'0"
⅜" Plate
⅜" Pl.
5'3"
17"
Sectional Elevation.
⅜" Steel Plate
½" Lead Washer
½"×1⅛" Bolt
1"×1½" Tire Bolt
5" Steel Beam
½" Lead Washer
⅜" Perforated Pl.
⅛" Rainbow Pack
Enlarged Detail "A".
FIG. 5. PRESS CURB.
Gas to Burner under Boilers
Fresh Air Inlet; this Coil is Perforated the entire under Surface with ⅛" Holes
Perforated Tray
4'0"
15"
50"
22"
12"
Final Outlet of Water from Entire Works
60"
Inlet Water from Condenser and Vacuum Pumps
8" Pipe
2" Pipe Support
12"
12"
Manhole
Gas and Water.
Gas to Burner under Boilers
6" Pipe
Hinged
Slush Box
Steel Wire Cloth
Skimmer
4" Pipe
Grease and Water.
FIG. 9. GREASE AND WATER SEPARATING TANK, GREASE WASHER AN
14'7½"
4"
2'6"
3"
½" Pipe
⅛" Copper Lining
Steel
23"
16"
10"
9'1½"
Cast Iron
⅛" Copper Lining
⅛" Copper Pl.
⅛" Leather
Cast Steel Brackets Fitted here
5"
3½"
10'3"
10'10"
Transverse Section.
Longitudinal Section.
FIG. 4. HYDRAULIC PRESS CYLINDER.

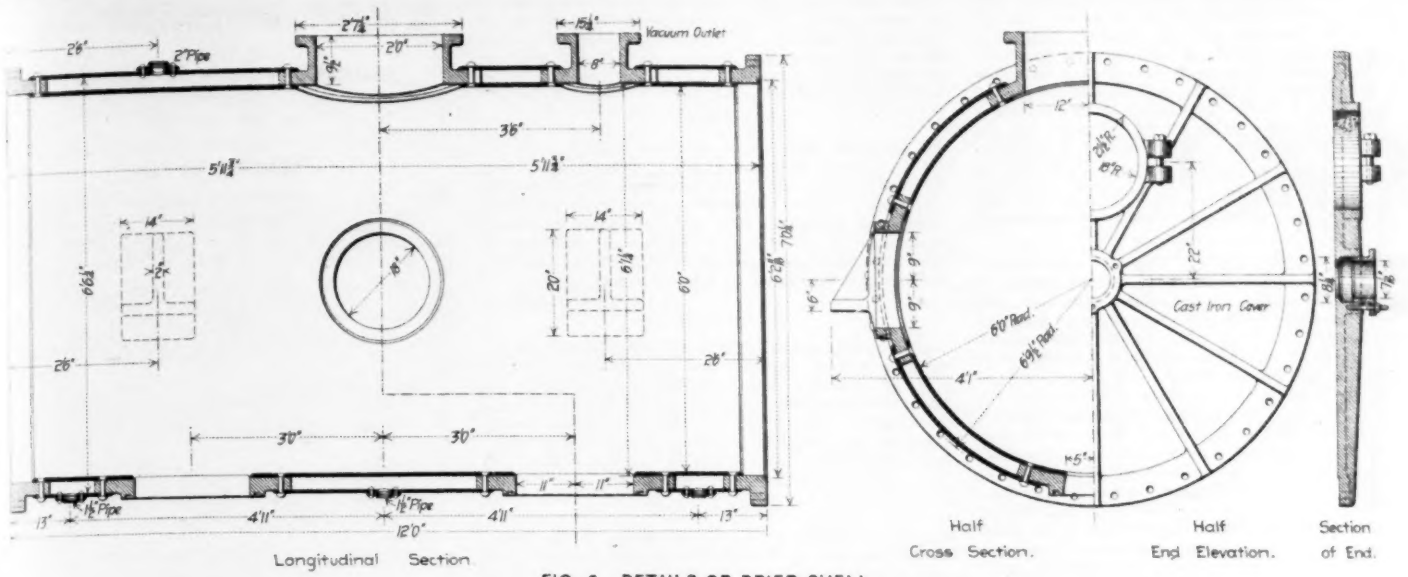
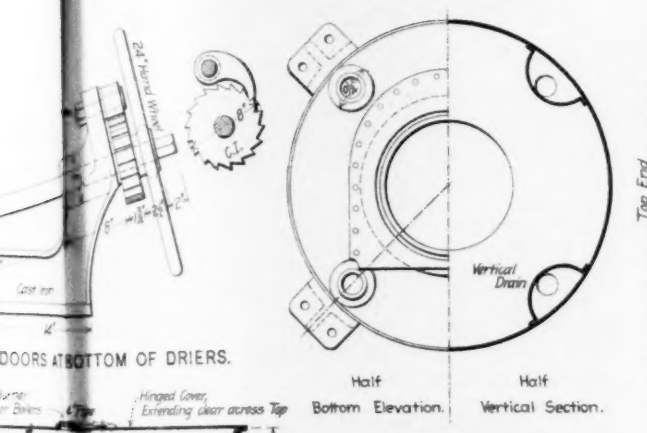
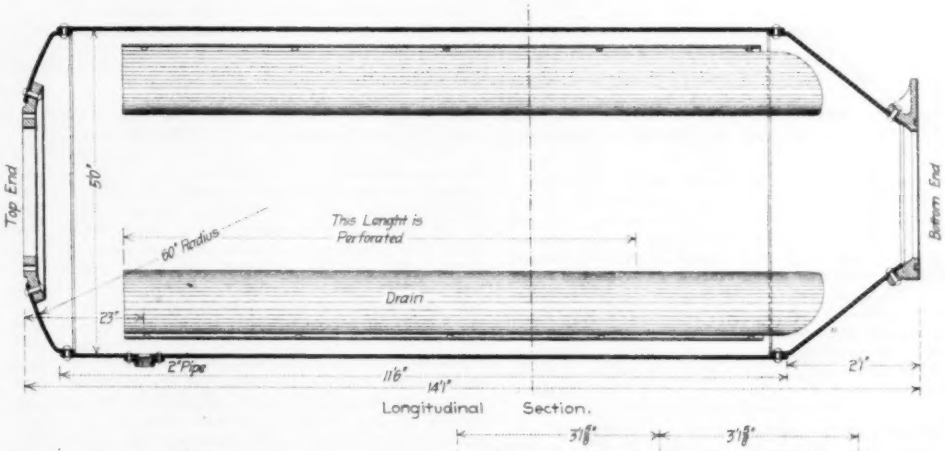
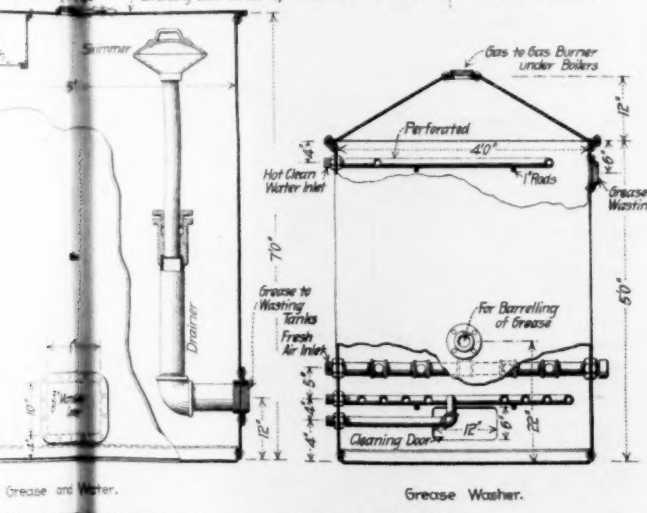
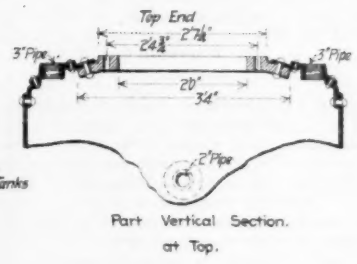


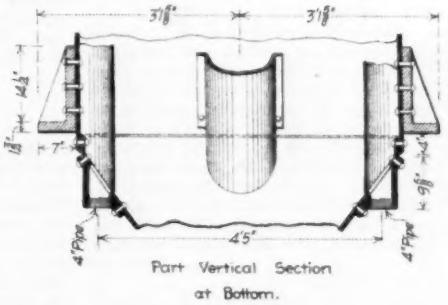
FIG. 6. DETAILS OF DRIER SHELL.





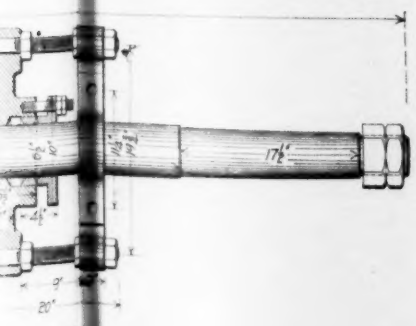






ANK, GREASE WASHER AND GAS AND WATER SEPARATOR.

FIG. 3. DETAILS OF DIGESTER.



GARBAGE REDUCTION WORKS

AT SYRACUSE, N. Y.

Emil Holthaus, Inventor;

Percy B. Taylor, Mechanical Engineer.

Cyrus Currier & Sons, Builders.

CHAS. HART, LITH., 90 VESEY ST., N. Y.